AMD
Smarter Choice

Harnessing the Power of Multiple GPUs

Games Developer Conference 2008

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Agenda

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- Why MGPU?
- Driver & Hardware Considerations
- Common Pitfalls & Solutions
- Performance Gains
- Call to Action

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Why MGPU?

Why MGPU?

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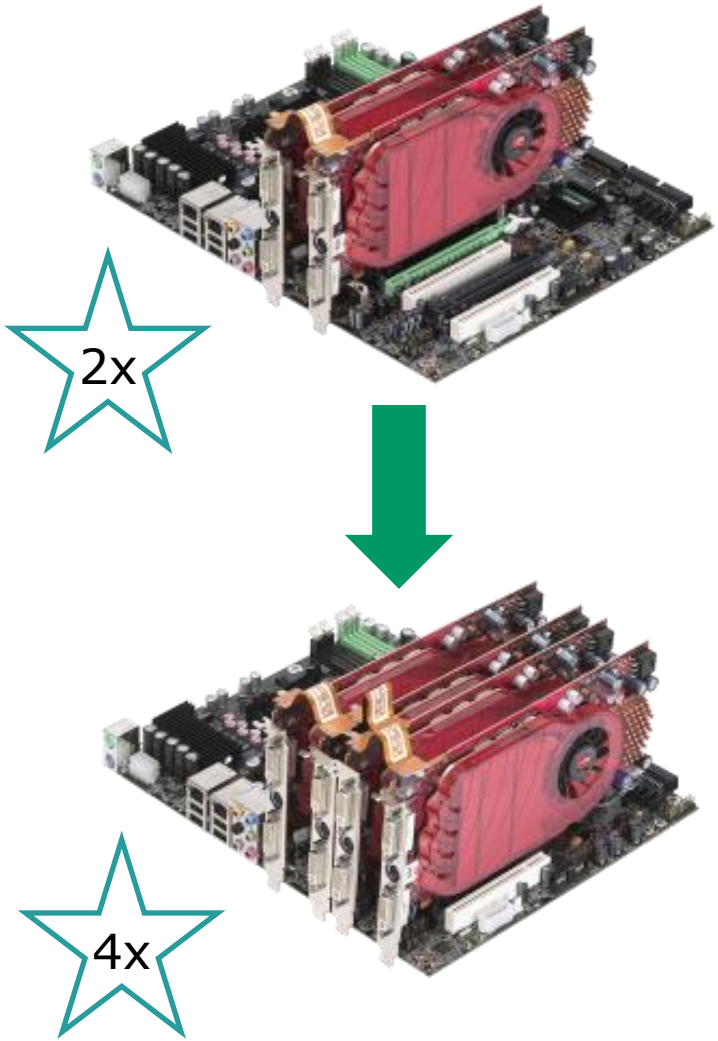
- MGPUs can be used to dramatically increase performance and visual quality
  - At higher screen resolutions
  - Especially with increased use of MSAA
- Many applications become GPU limited at higher screen resolutions
  - High resolution monitors => mainstream affordability
- Achieve next generation performance on today‘s HW
  - Prototype your next engine
- Provides an upgrade path for mainstream parts

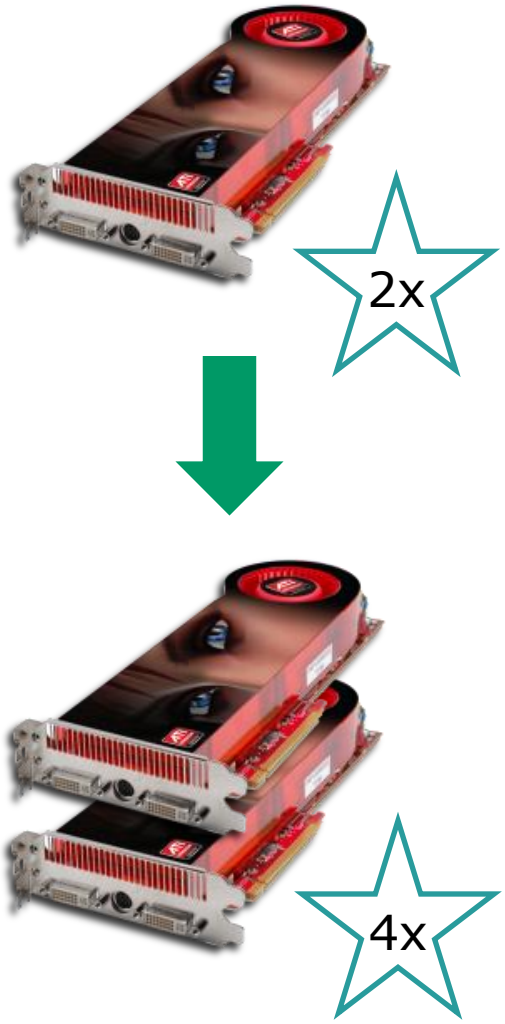
Multiple Boards

- An increasing number of motherboards can accept 2 or more discrete video cards
- Connected by high speed crossover cables
- Now possible to fit 4 Radeon HD3850 boards to a single motherboard
- CrossFireX technology allows you to harness that performance



Multiple GPUs per Board

- The Radeon HD3870 X2 is a single-board multi-GPU architecture
  - AFR is on by default
- Heavy peer to peer communication
  - Bi-directional 16x lane pipe connecting the 2 GPUs
- CrossFireX supports 2 HD3870 X2 boards for Quad GPU performance



Hybrid Crossfire

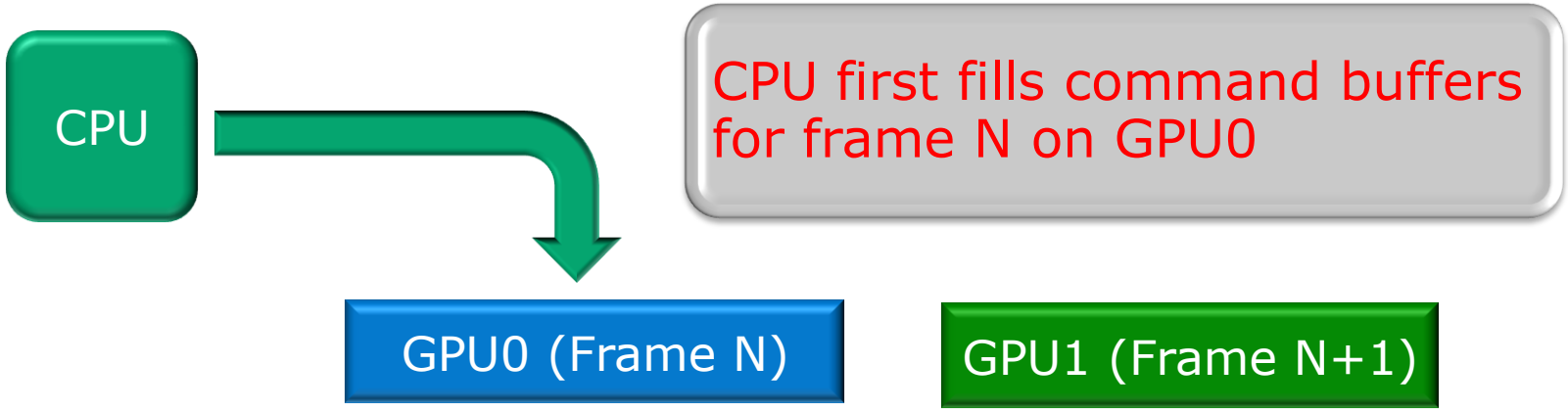
- Combination of integrated and discrete graphics
- 3D graphics performance boost
  - Laptops
  - Mainstream desktop PCs
- Use less power during non-taxing graphical tasks

CrossFire Rendering Modes

- Split Frame Rendering / Scissor
  - Screen is divided into number of GPUs
  - Dynamic load balancing

- Alternate Frame Rendering
  - GPUs take alternate frames
  - Vertex processing not duplicated
  - Highest performing mode

How does AFR Work?



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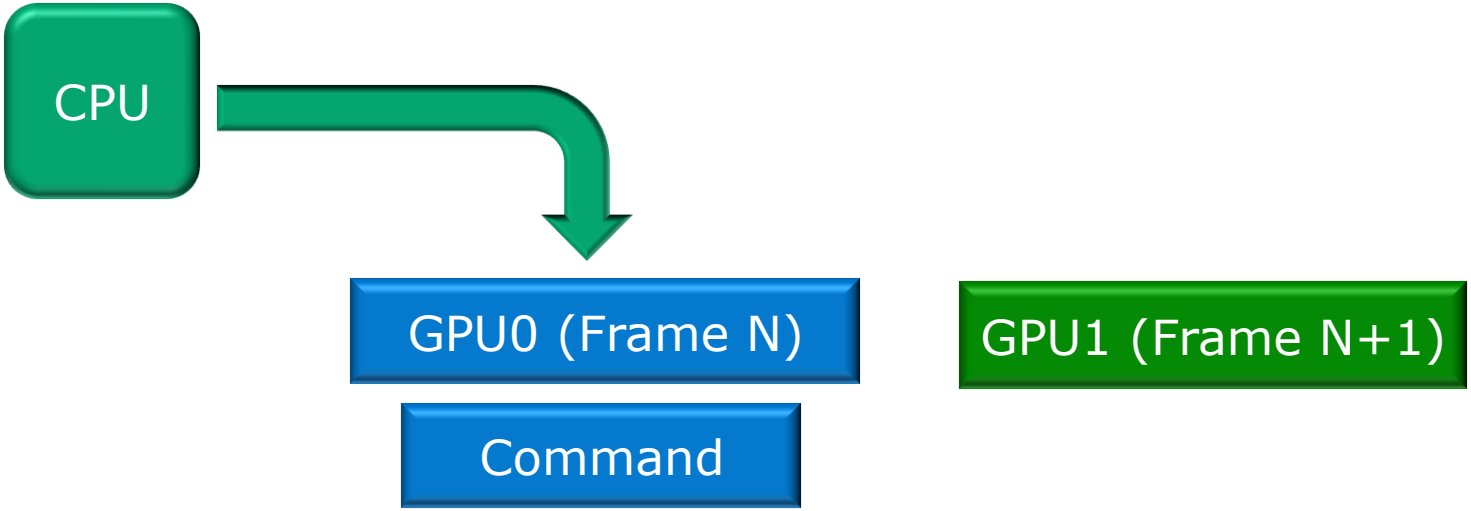

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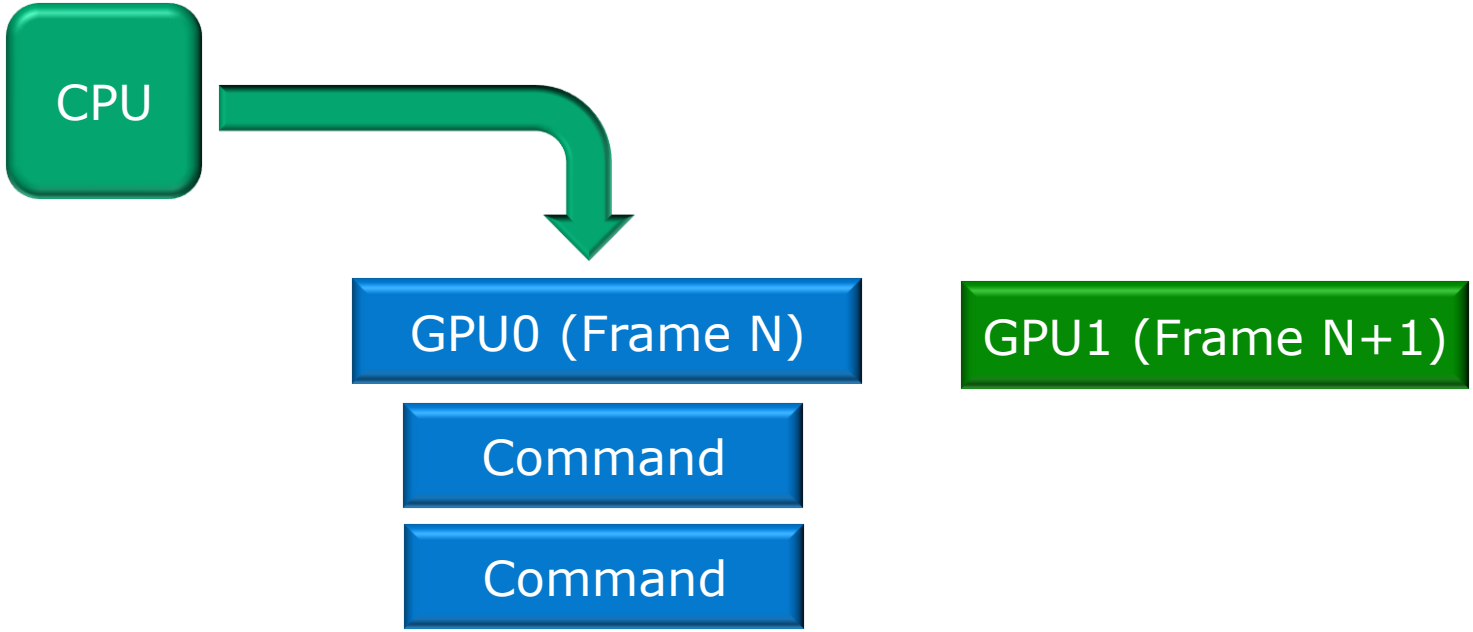

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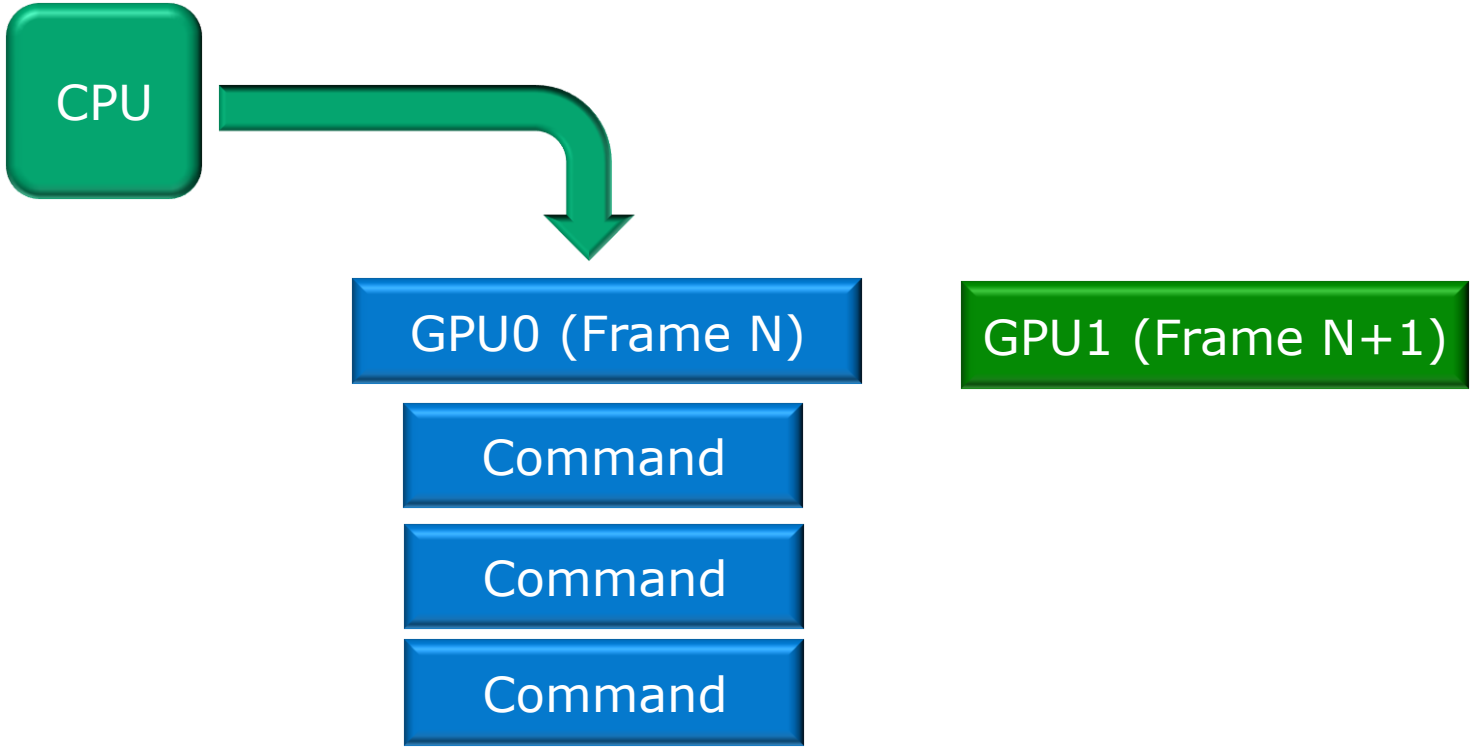

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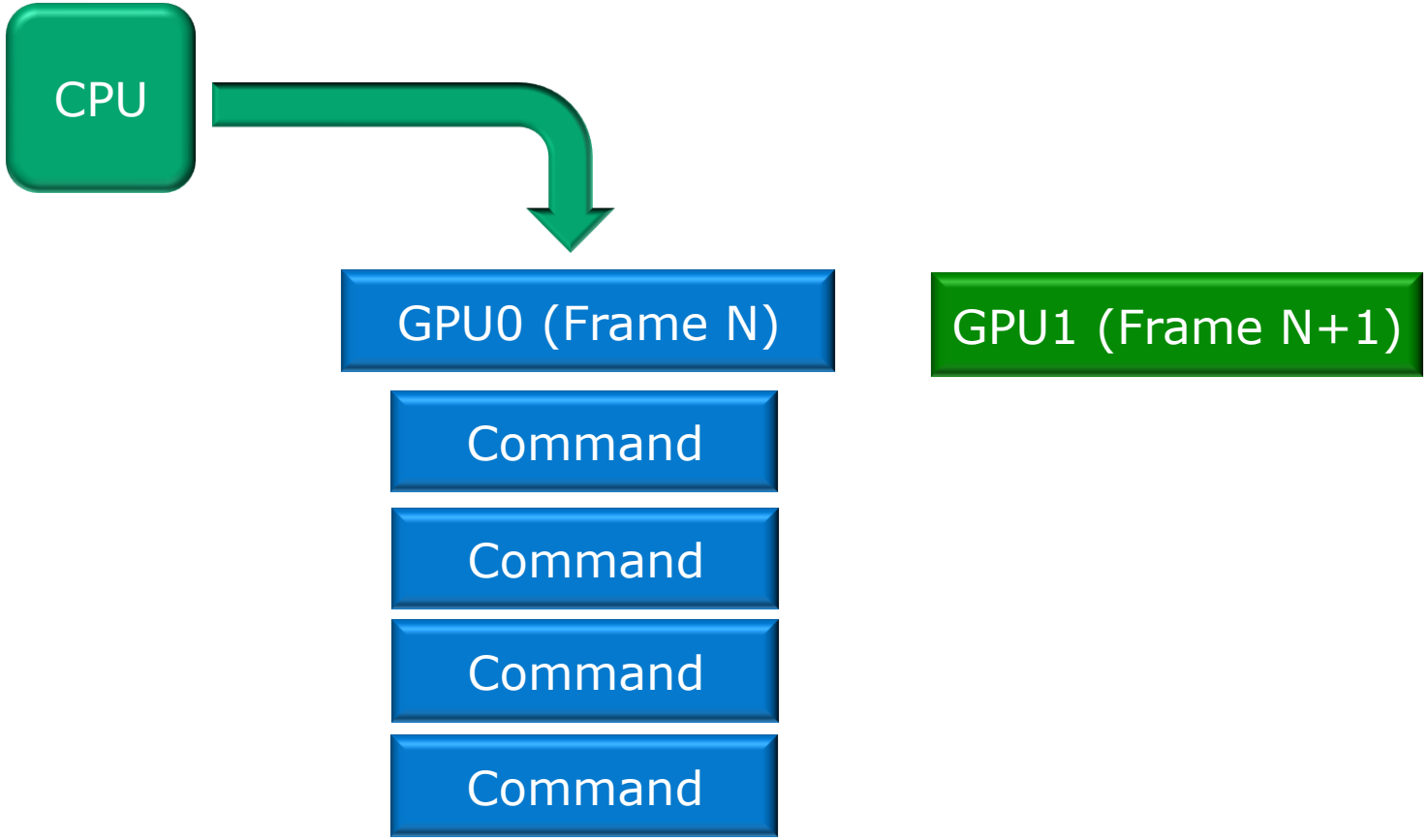

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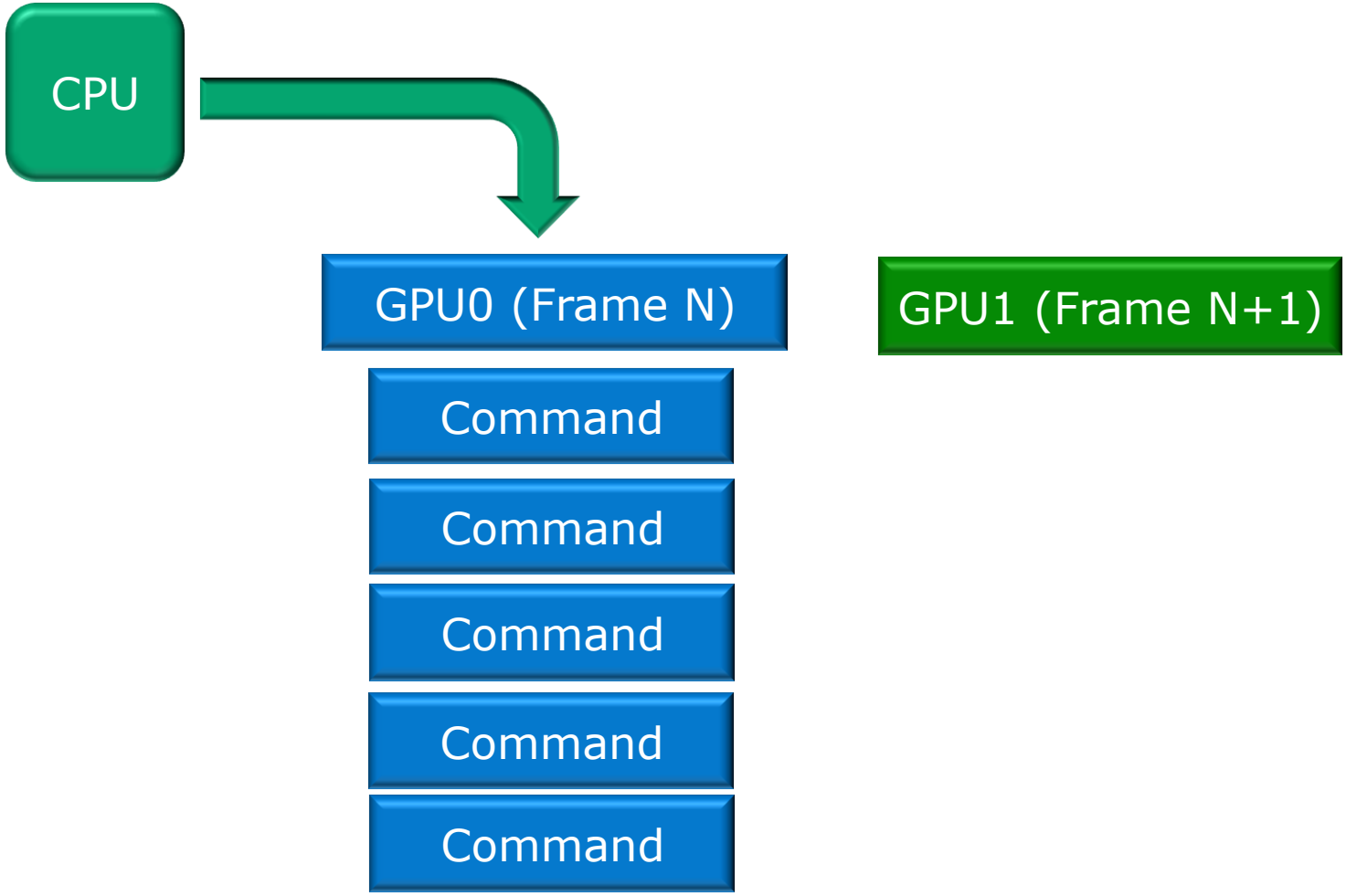

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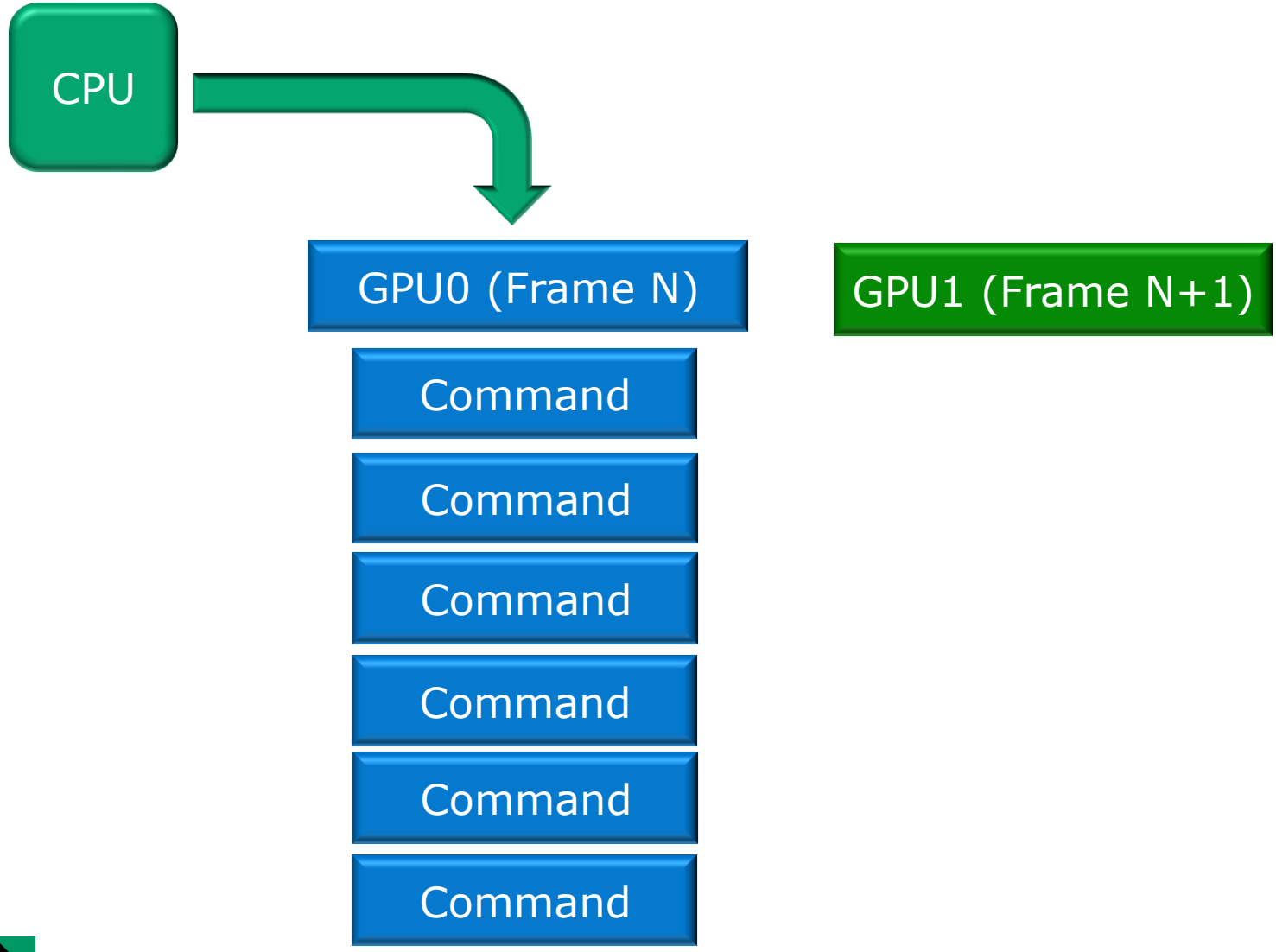

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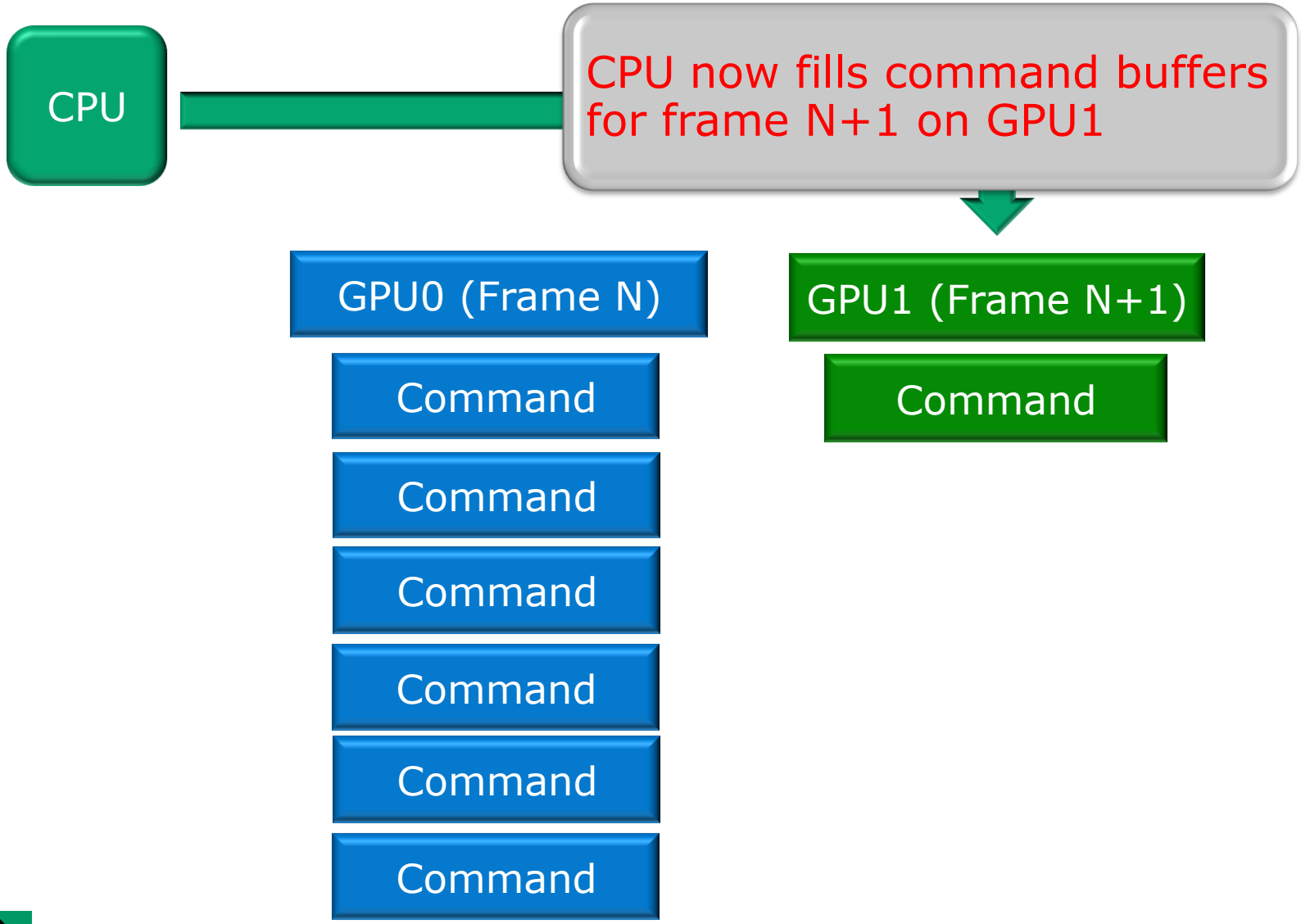

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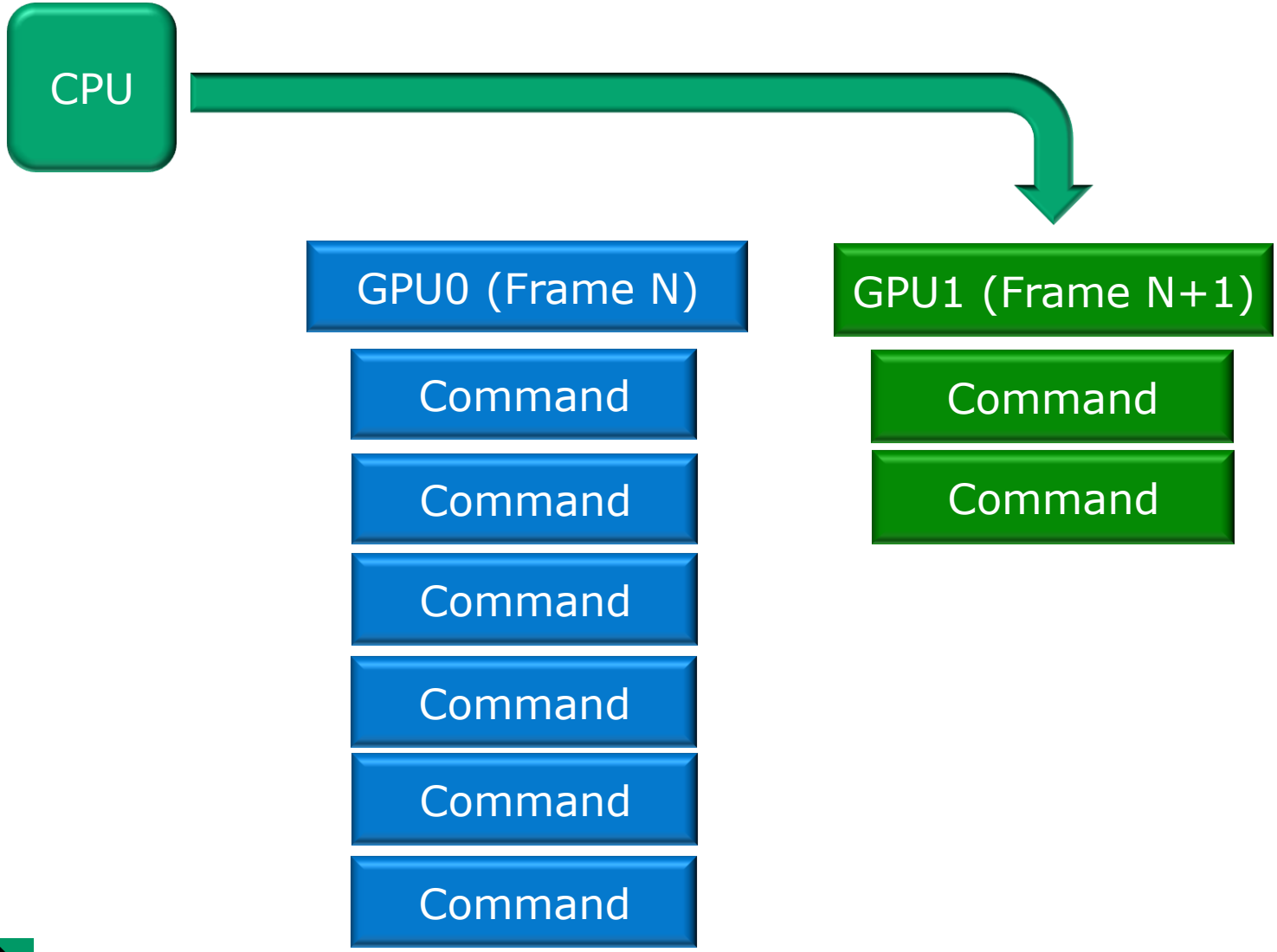

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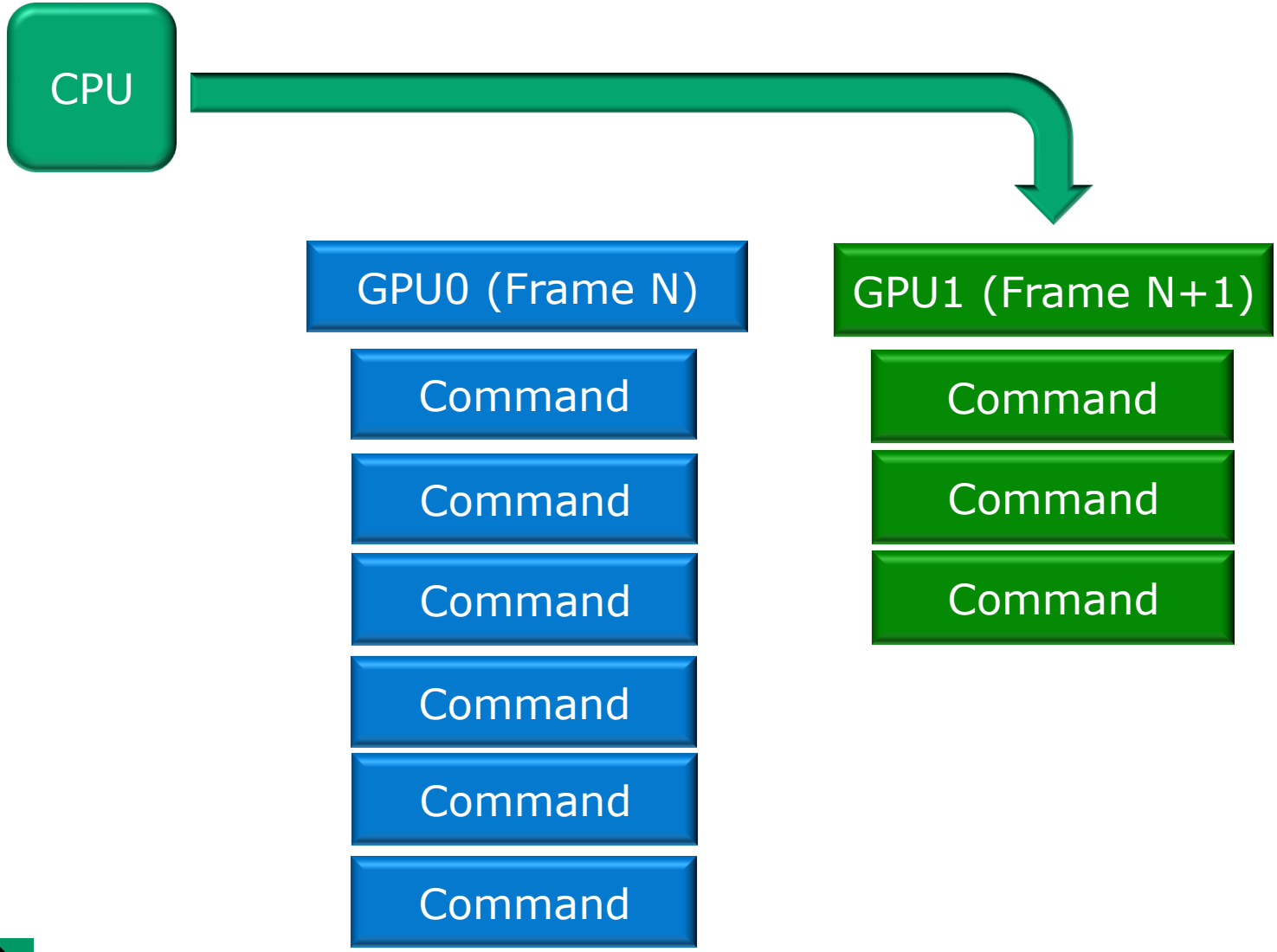

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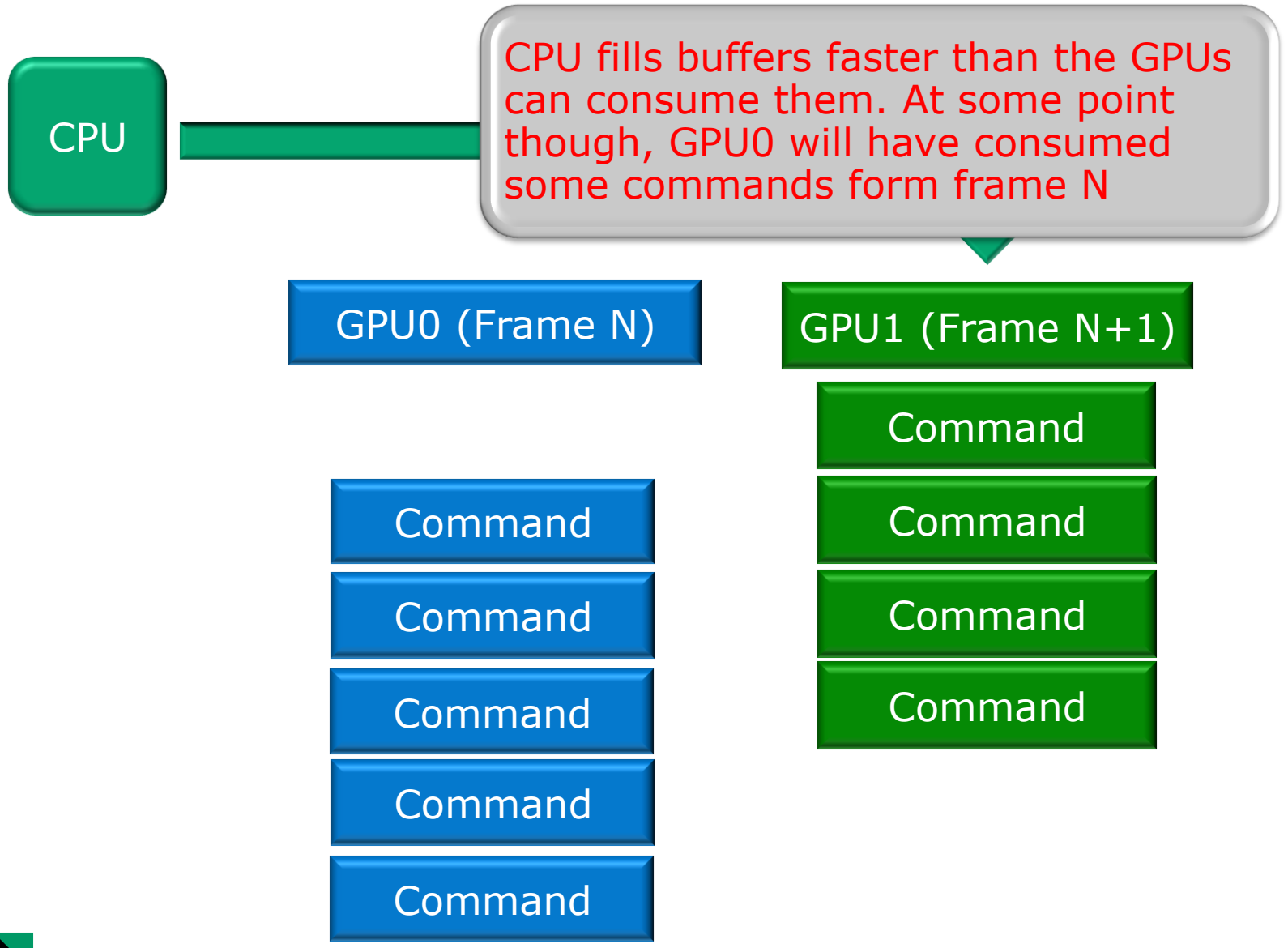

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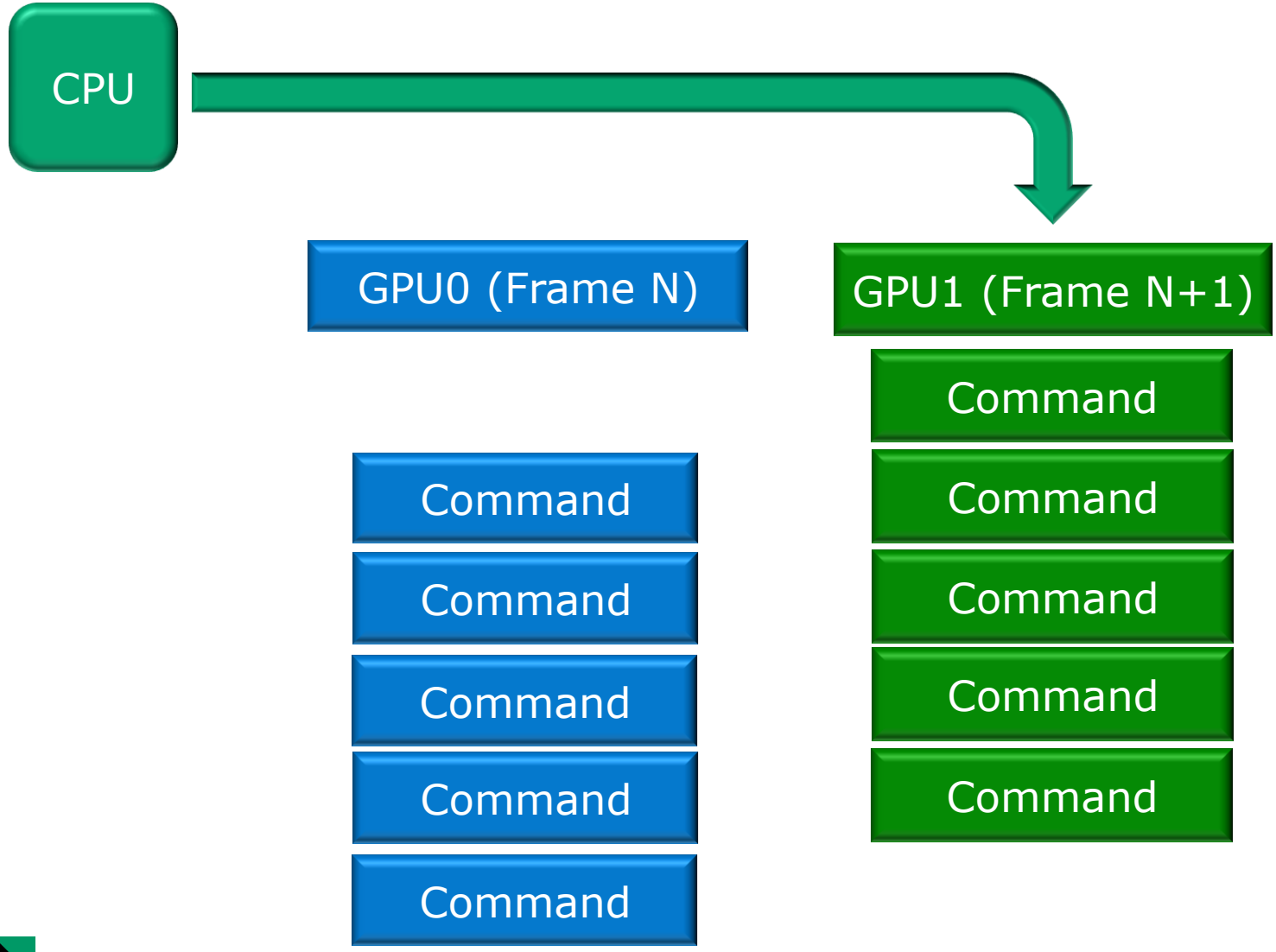

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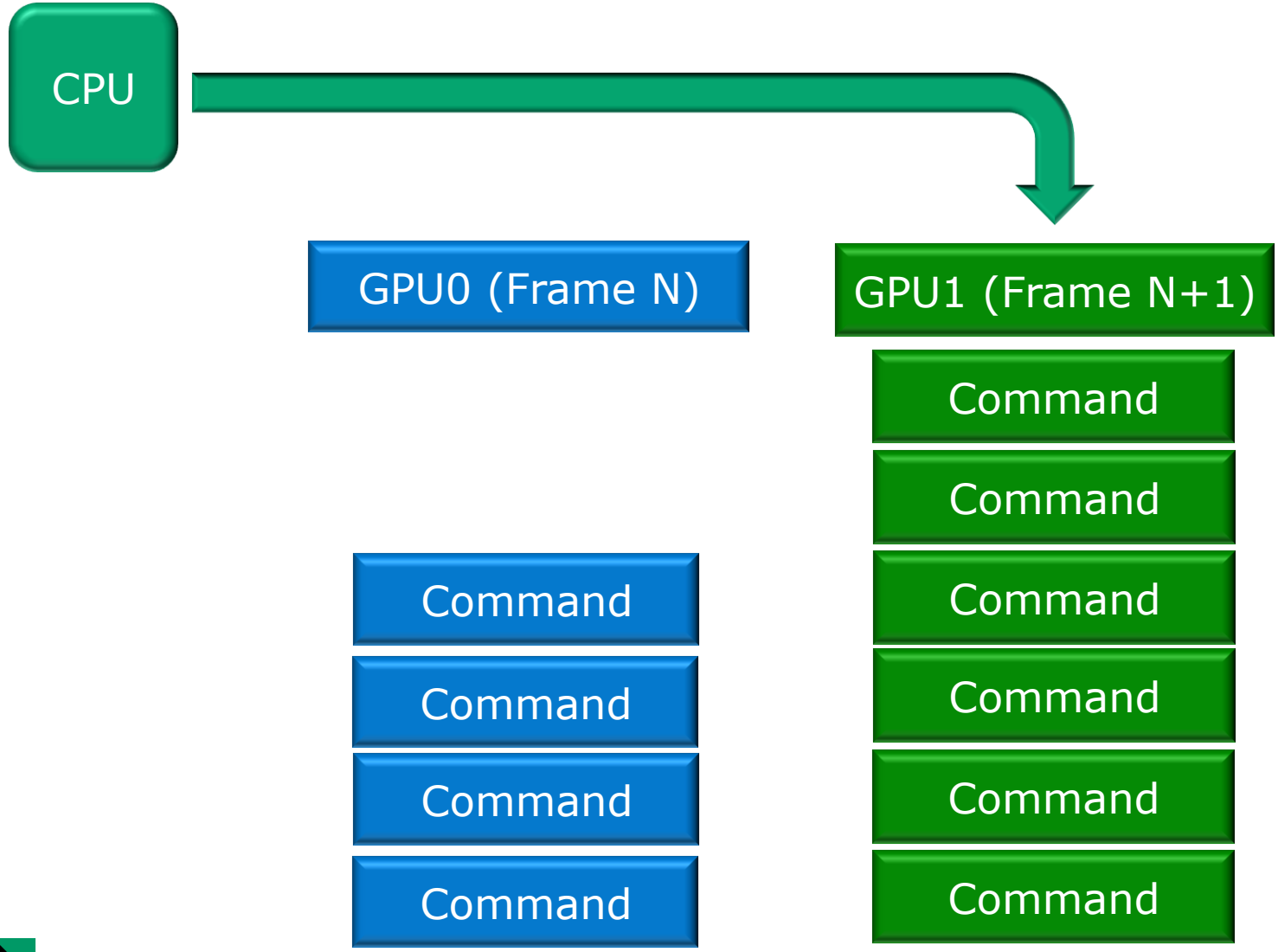

Driver & Hardware Considerations

Hardware Considerations

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- Current MGPU setups are not shared memory architectures
  - Resources placed in local video memory are duplicated for each GPU
- Driver initiates peer to peer (P2P) copies to keep resources in sync
  - On some chipsets this may involve the CPU
  - Synchronizes all GPUs
  - Very heavy impact on performance that can even result in negative scaling

Driver Modes

- Compatible AFR Mode
  - Default mode
  - Driver checks for AFR unfriendly behaviour
  - Will peer to peer (P2P) copy stale resources
- Full AFR Mode (Application Profile)
  - Driver recognises EXE name
    - Use a unique name and don‘t change it
  - Behaviour fully guided by profile
  - Best performance – no checking
  - Rename EXE to “AFR-FriendlyD3D.exe“
    - Use “AFR-FriendlyOGL.exe“ for OpenGL
    - No checking : Speed & compatibility test

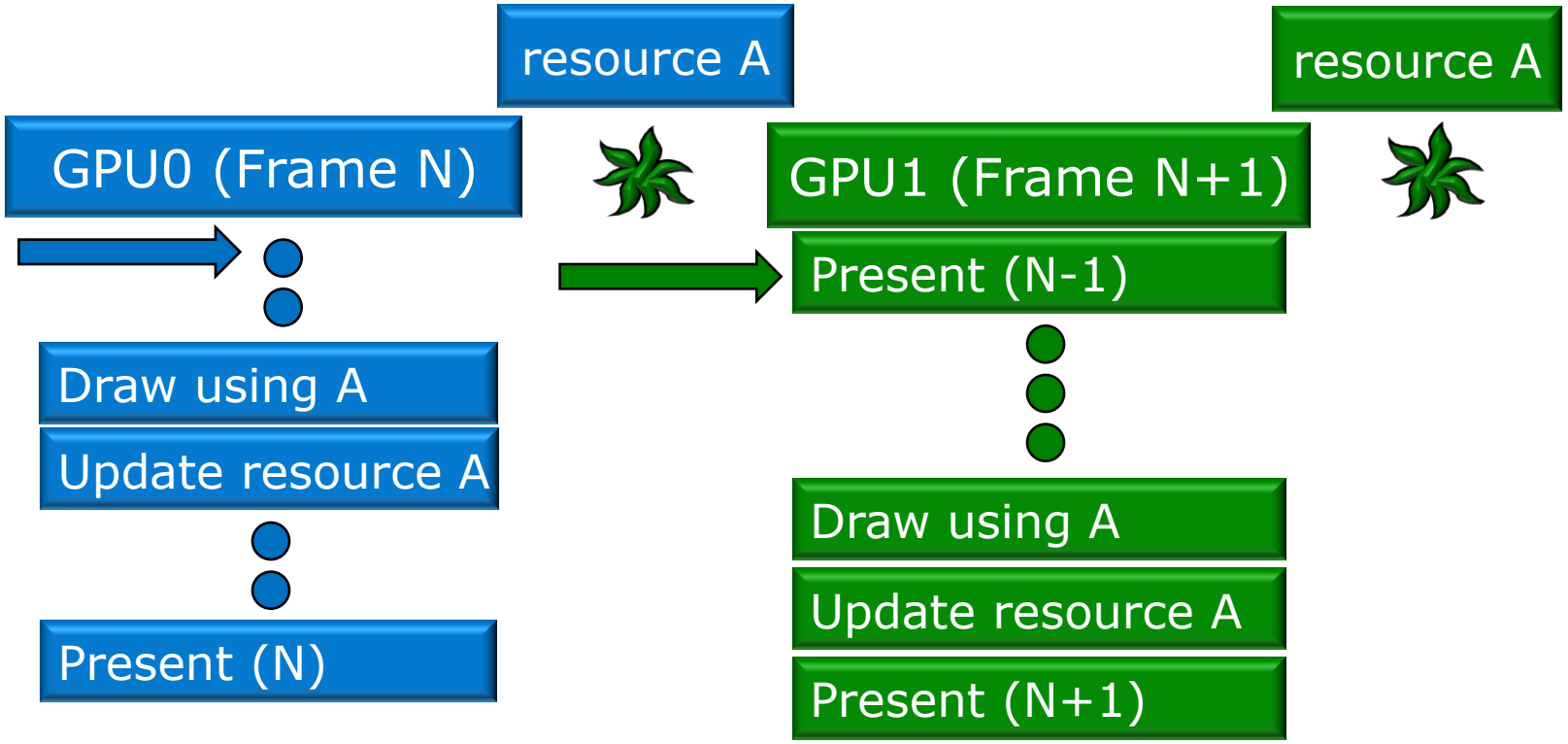
Detecting the Number of GPUs

AMD Smarter Choice

- Visit http://ati.amd.com/developer
  - Download project called "CrossFire Detect"
- Statically link to:
  - "atimgpud_s_x86.lib" 32 bit version
  - "atimgpud_s_x64.lib" 64 bit version
- Include header file:
  - "atimgpud.h"
- Call this function:
  - INT count = AtiMultiGPUAdapters();

Common Pitfalls & Solutions

Pitfall: Dependencies Between Frames



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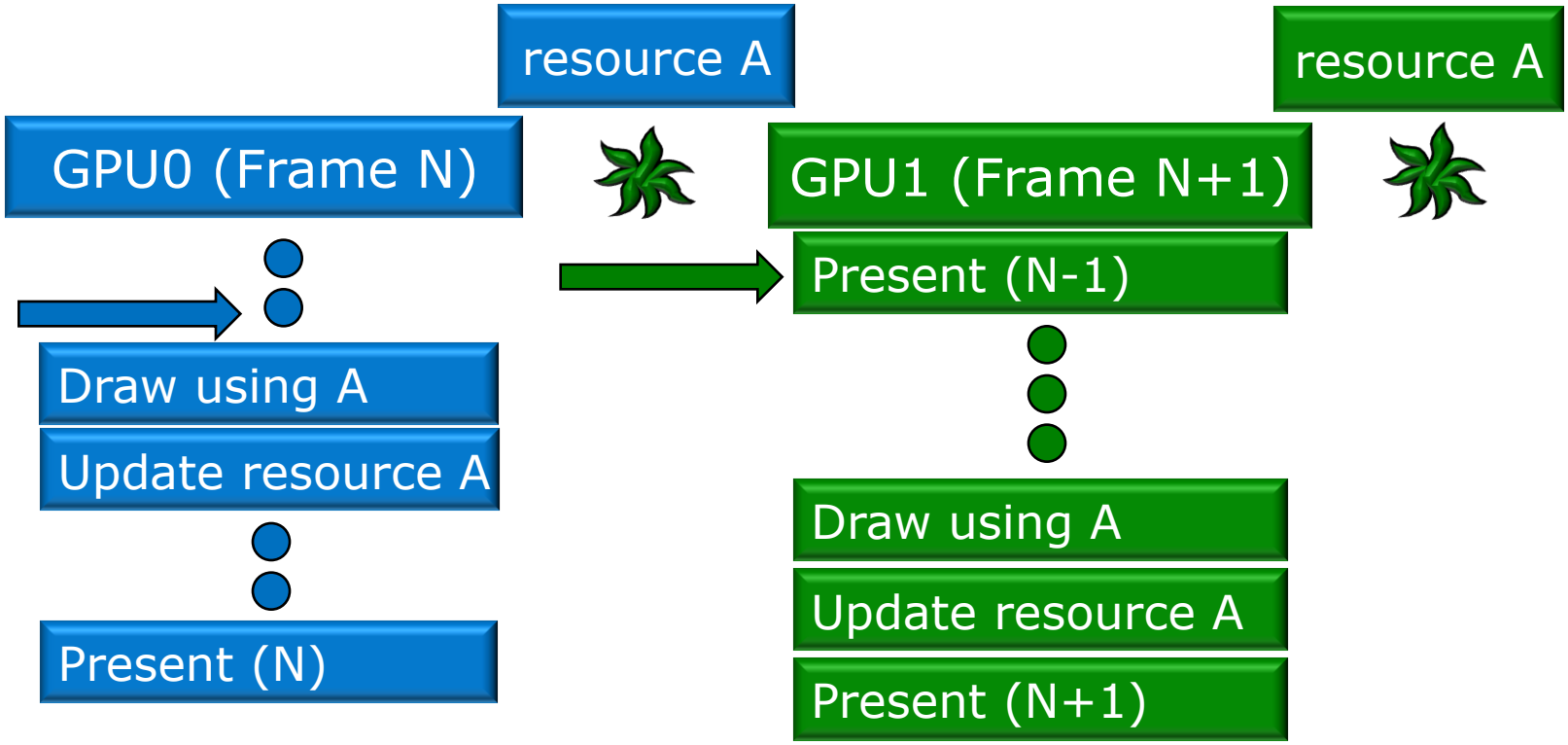

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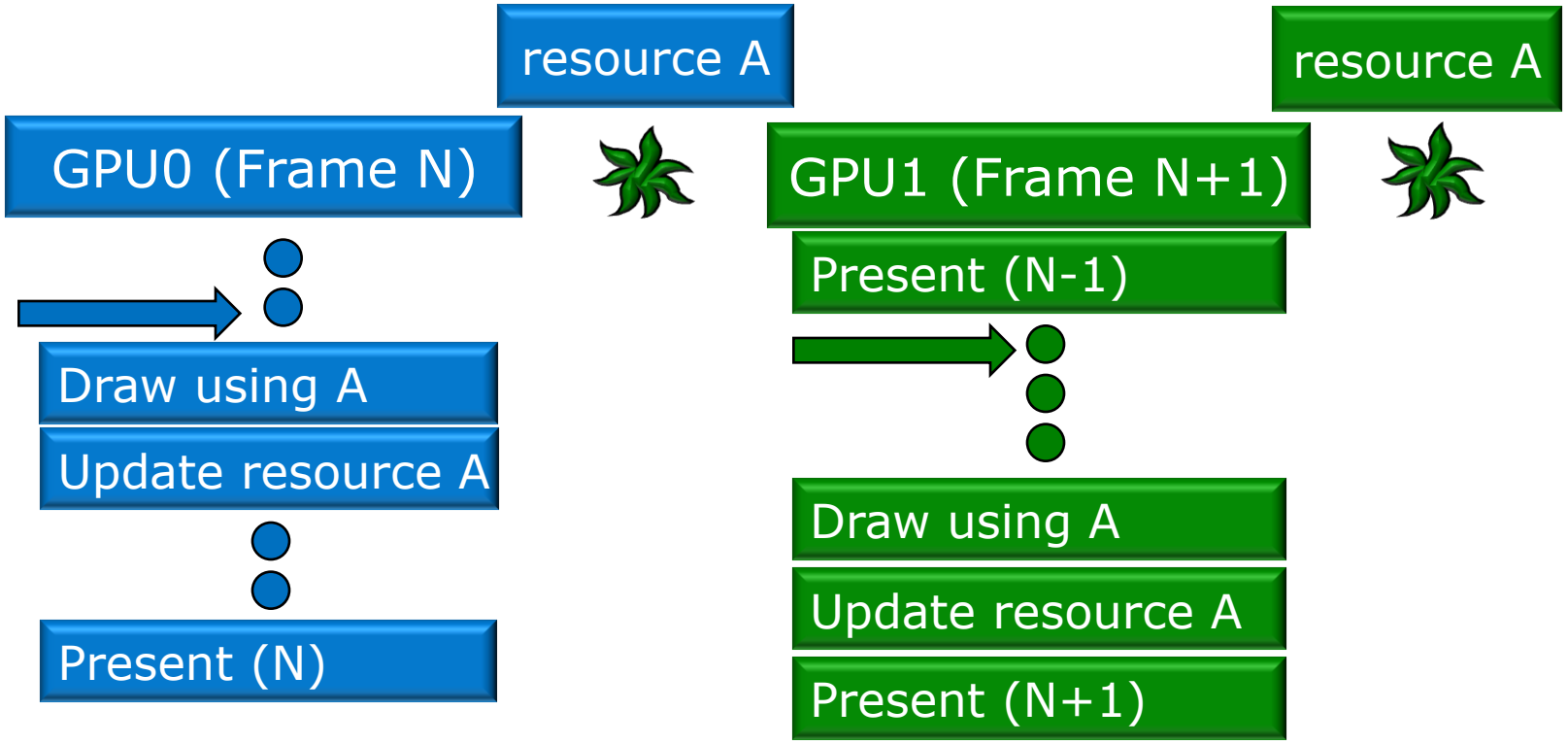

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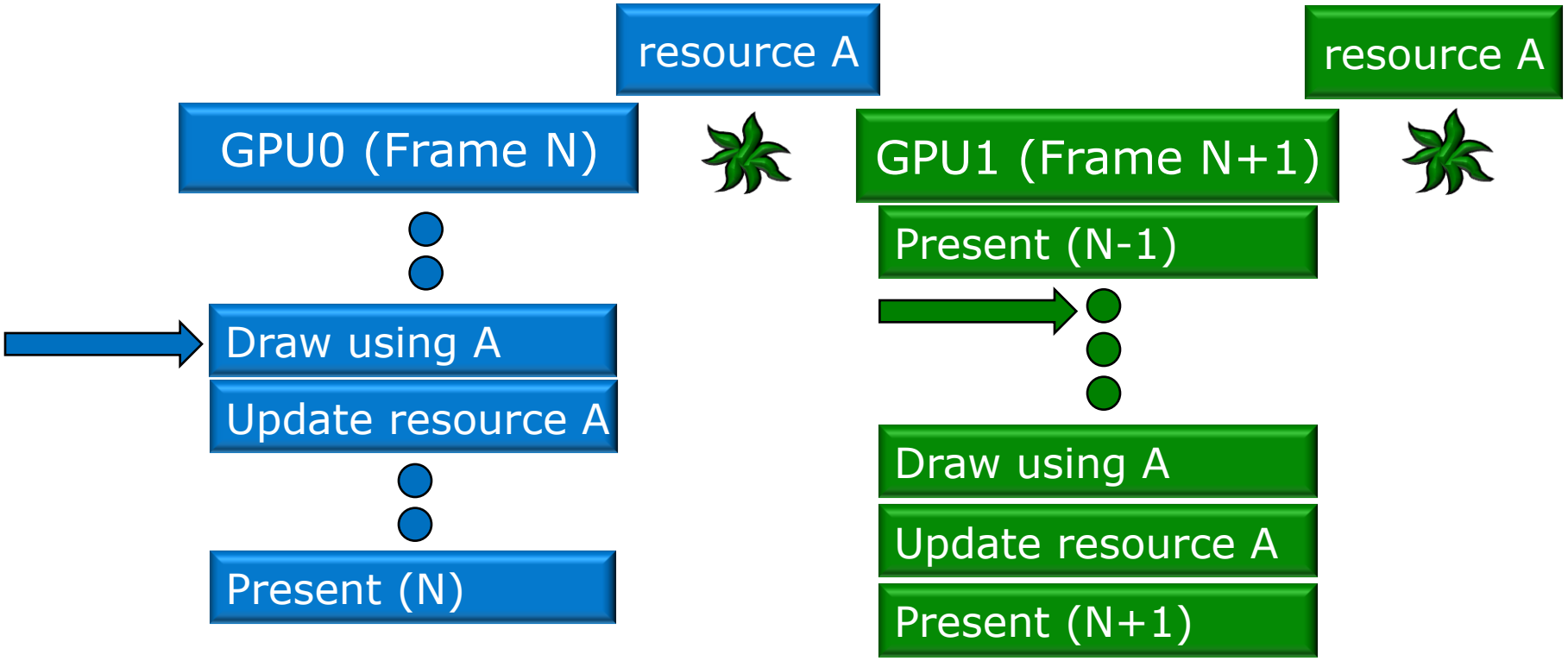

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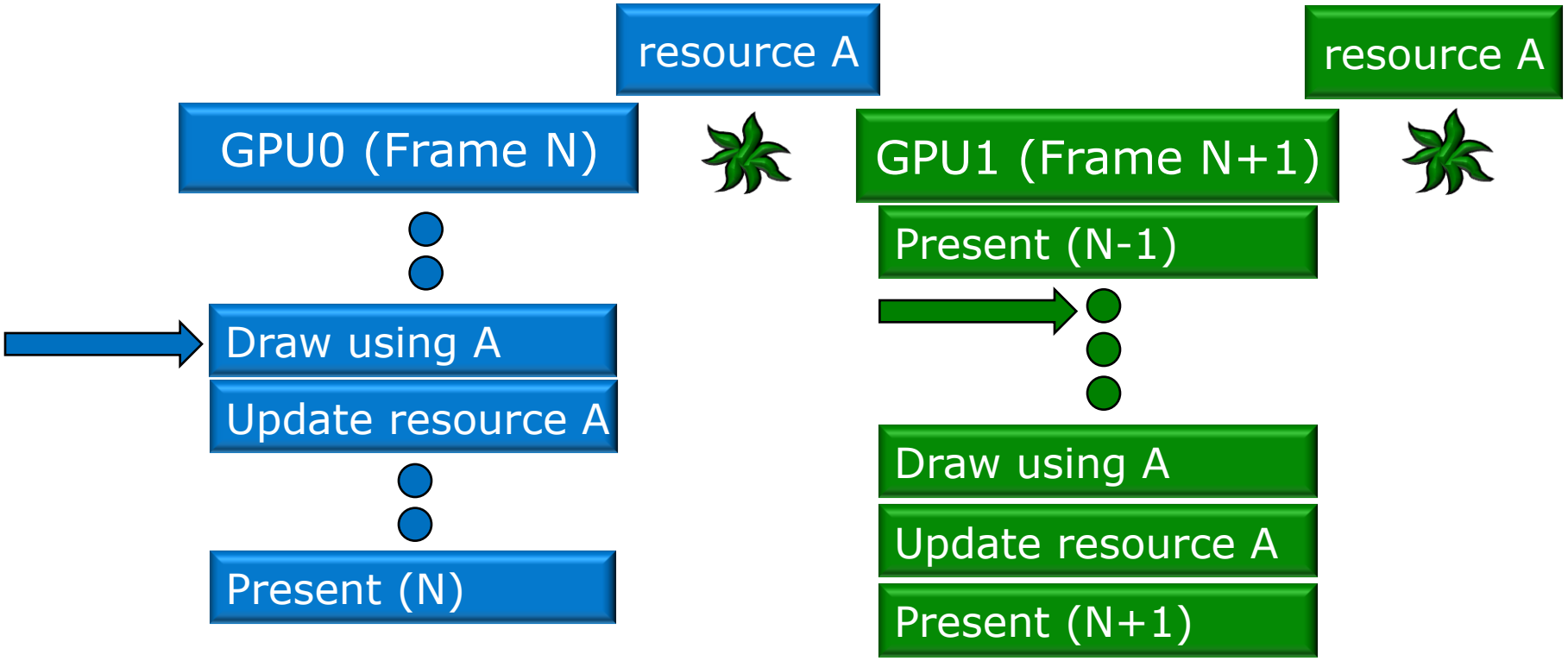

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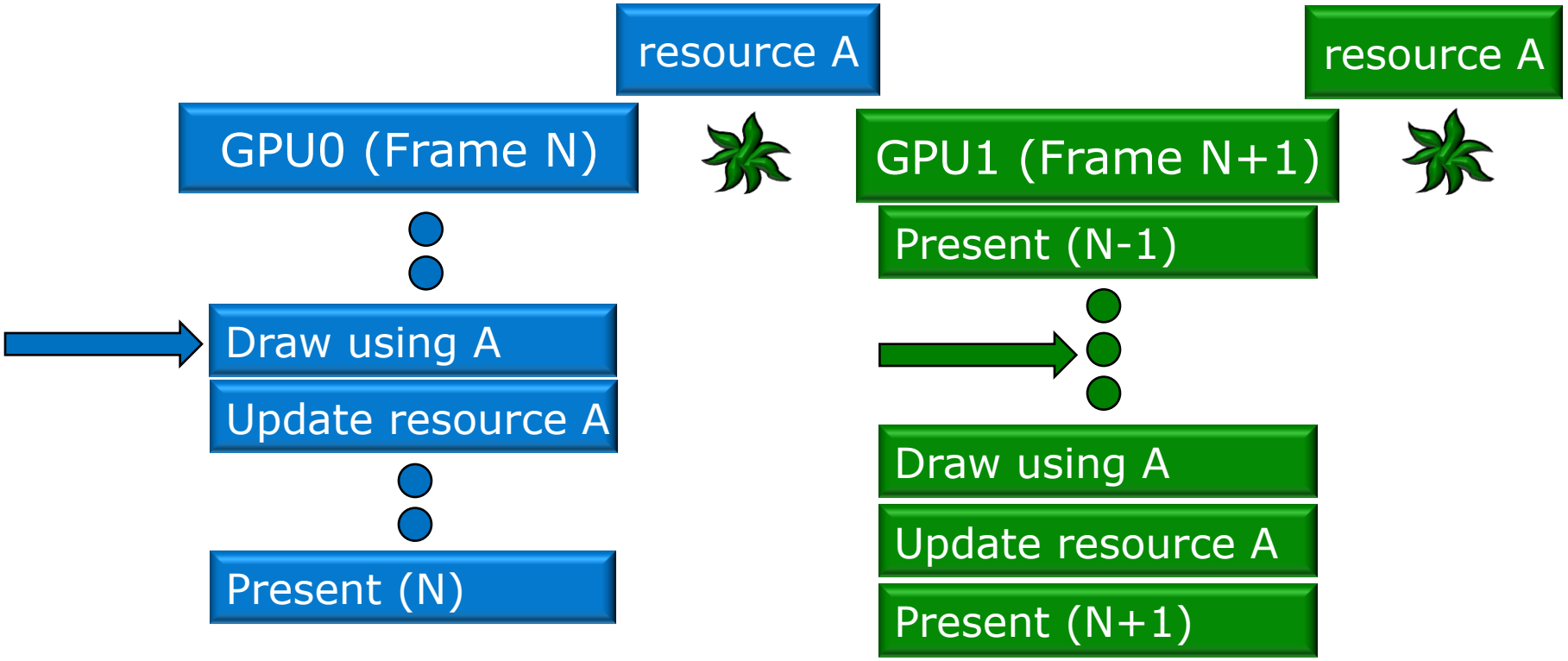

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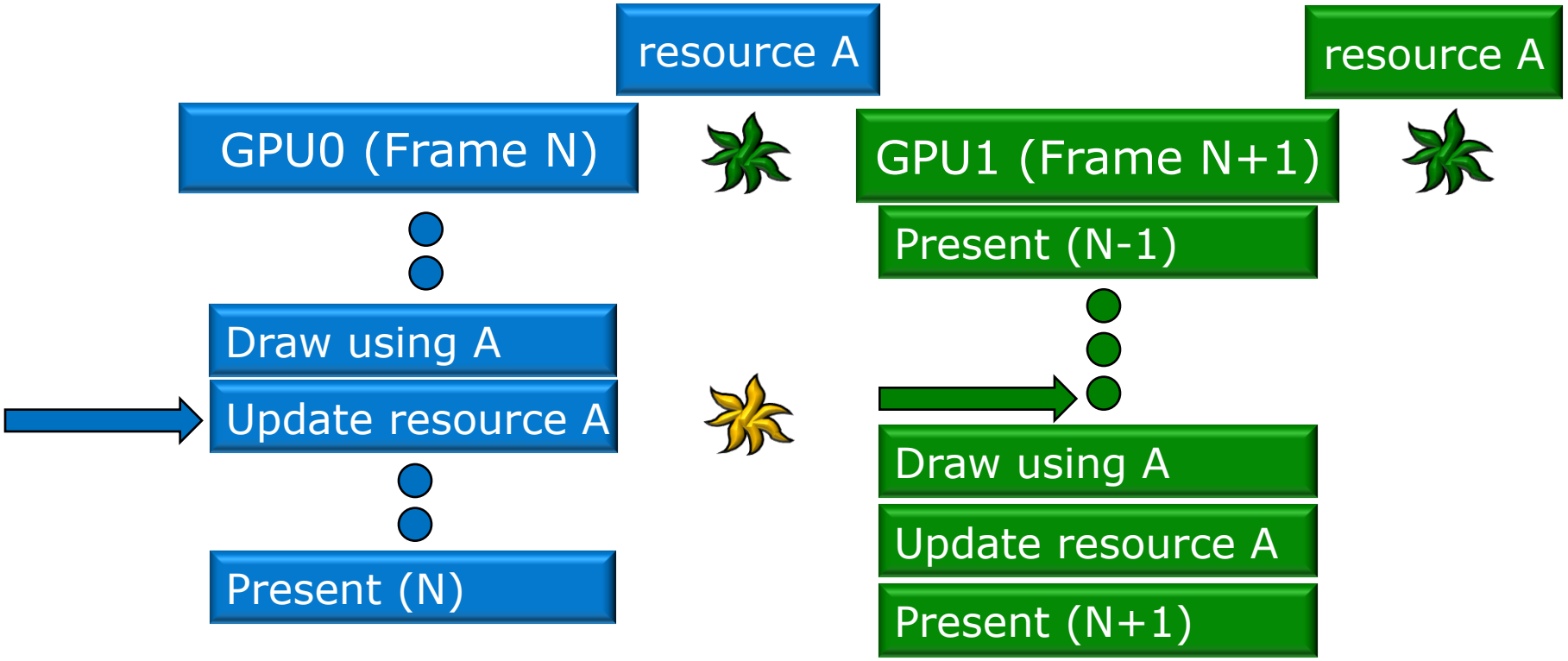

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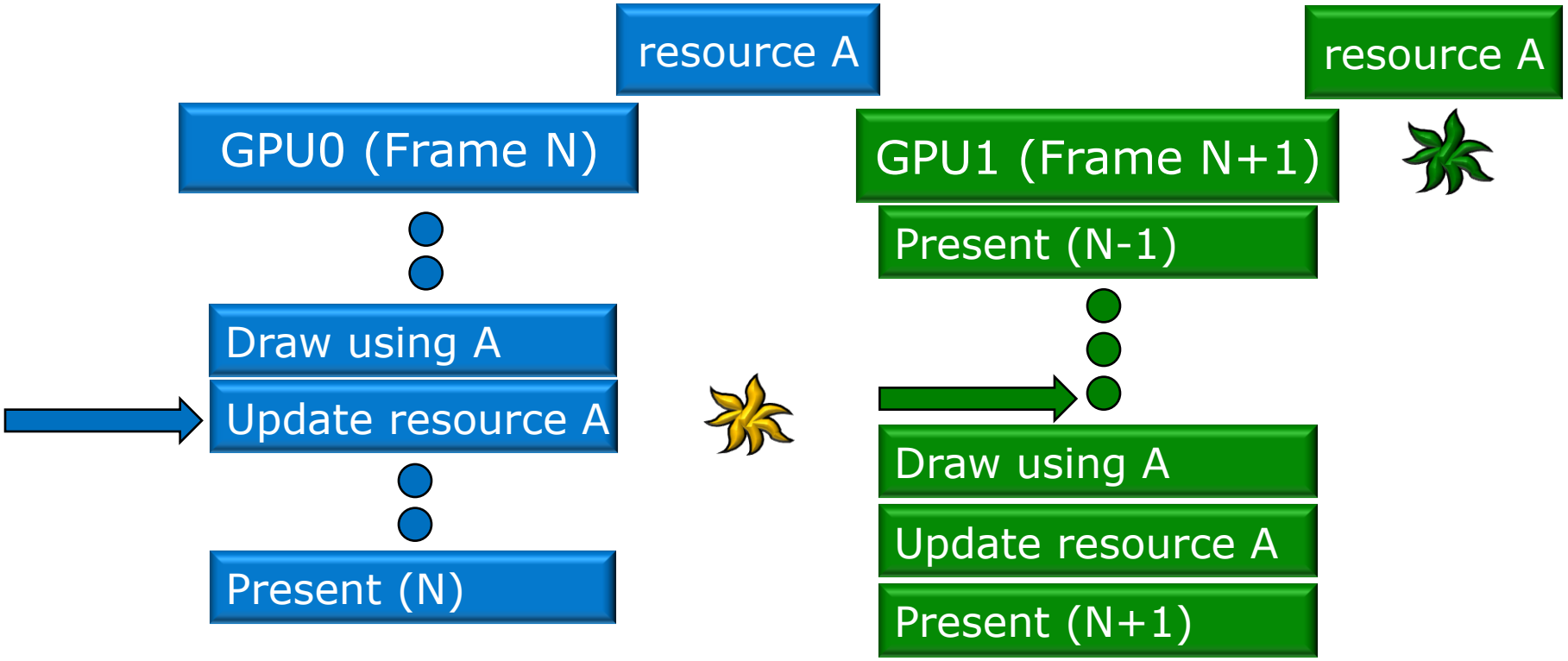

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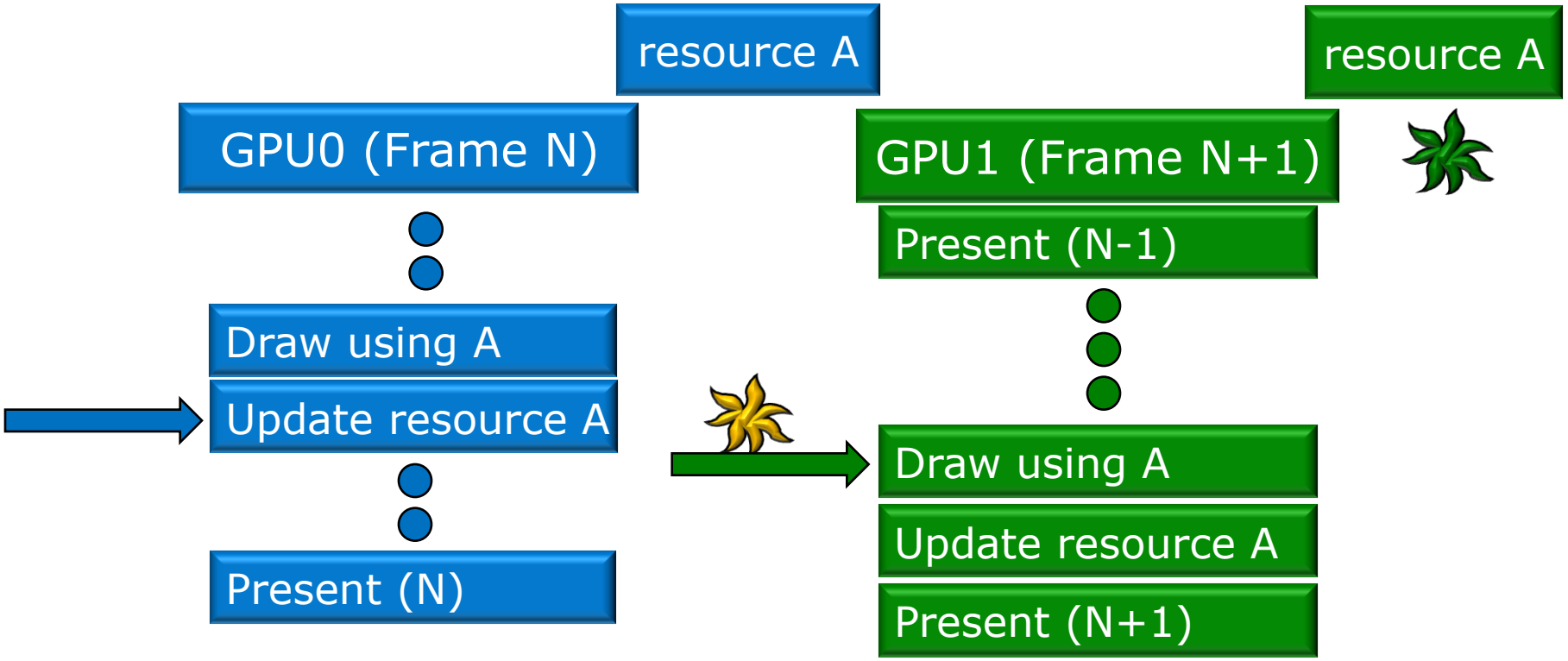

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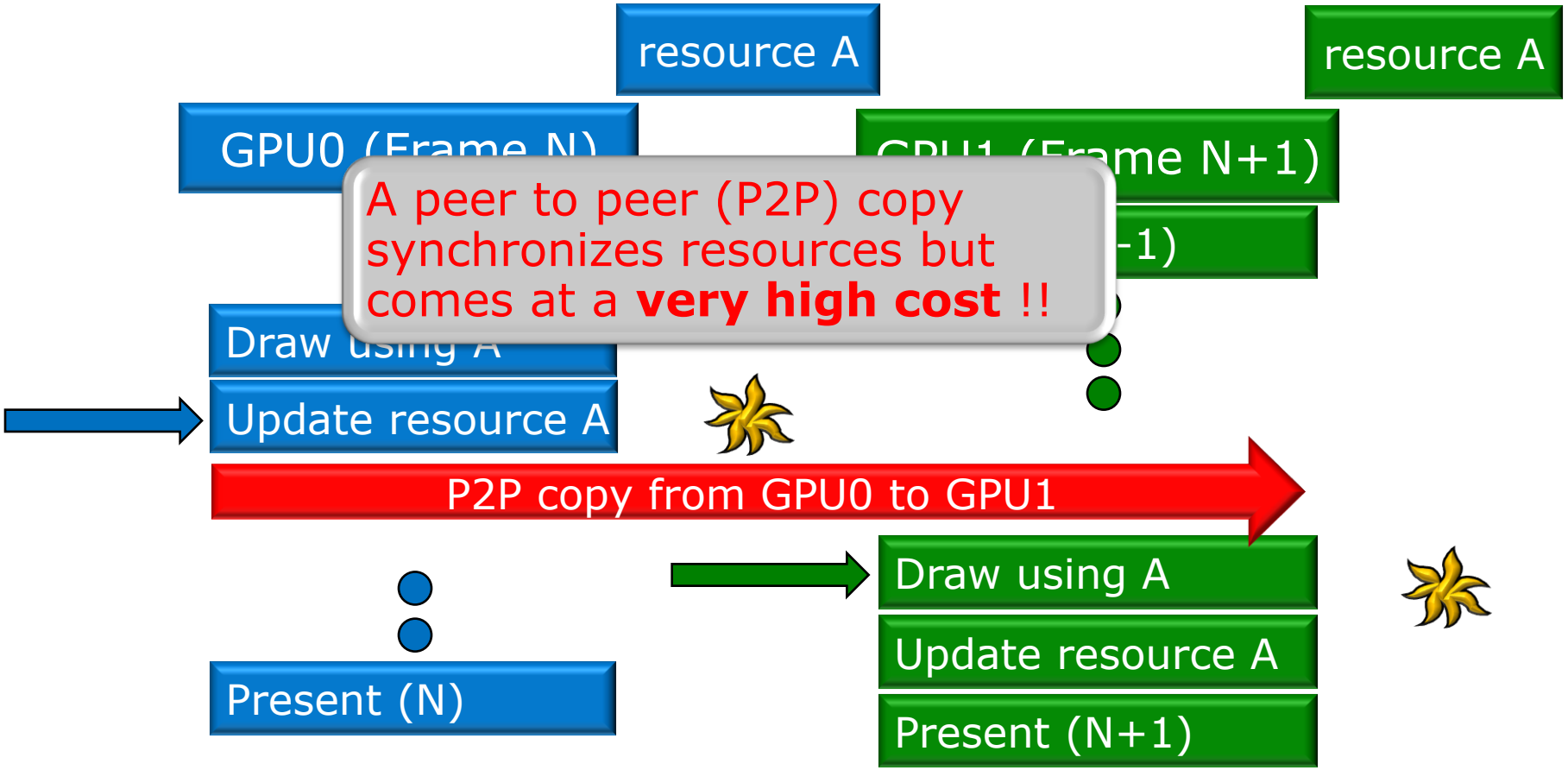
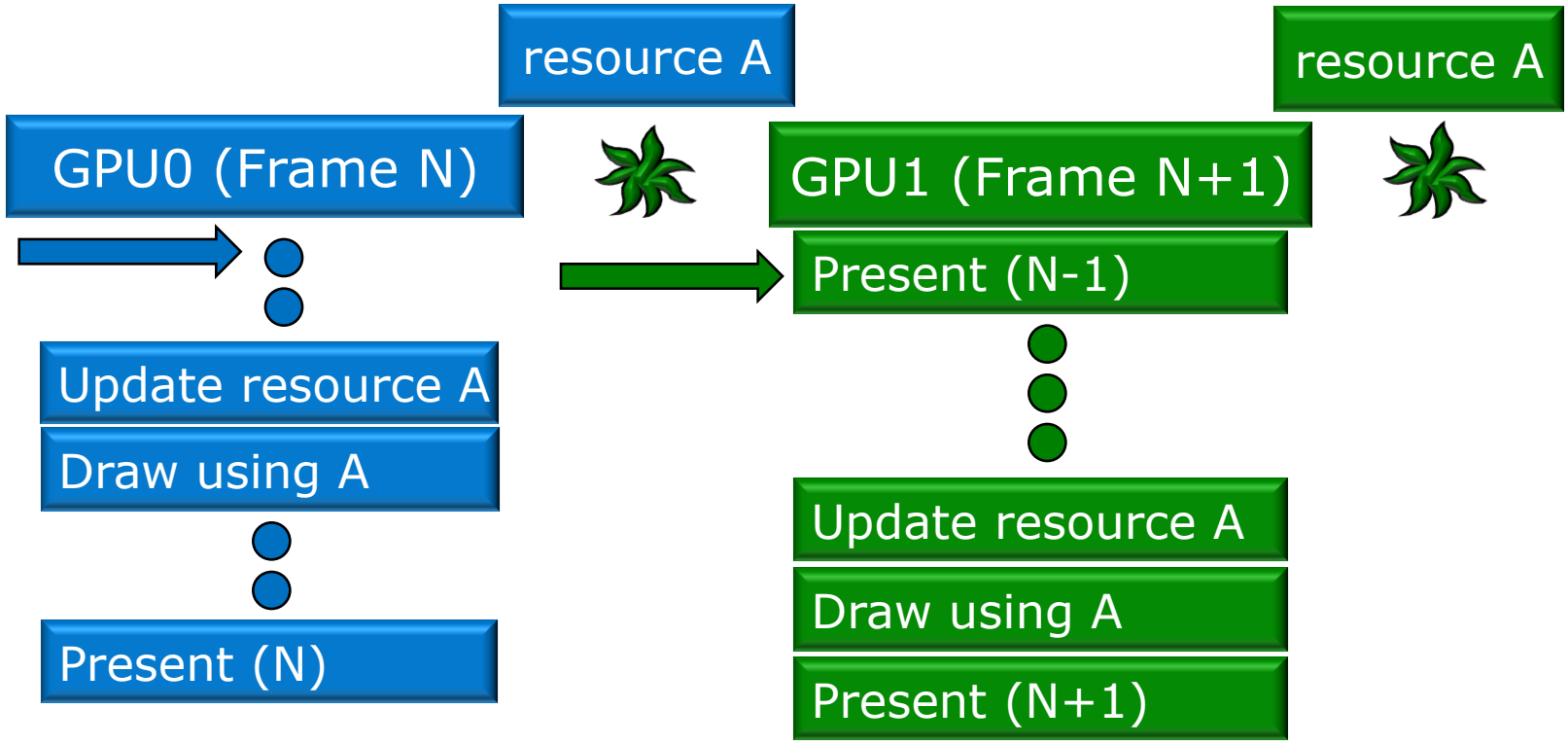


Solution: Resources that Change Every Frame



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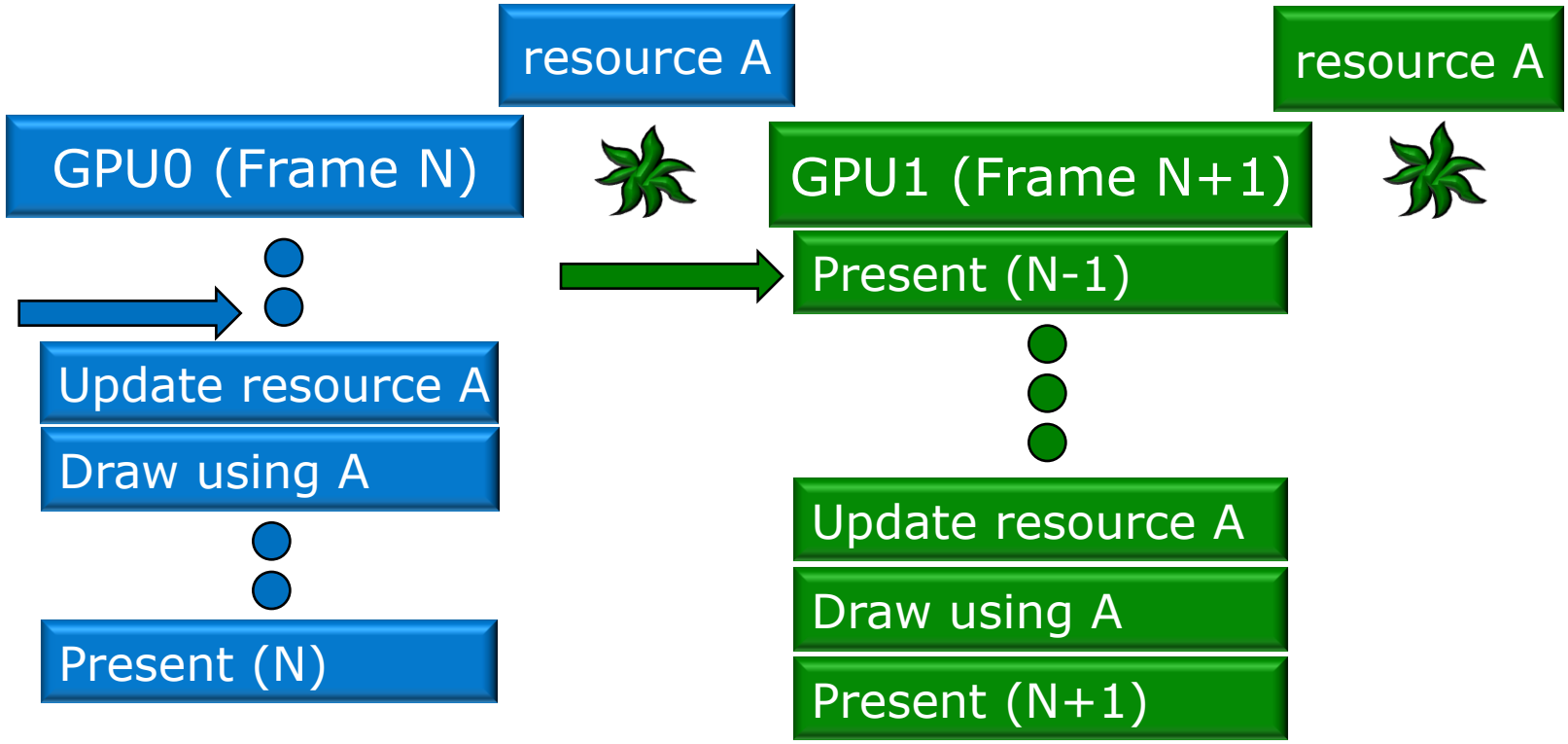

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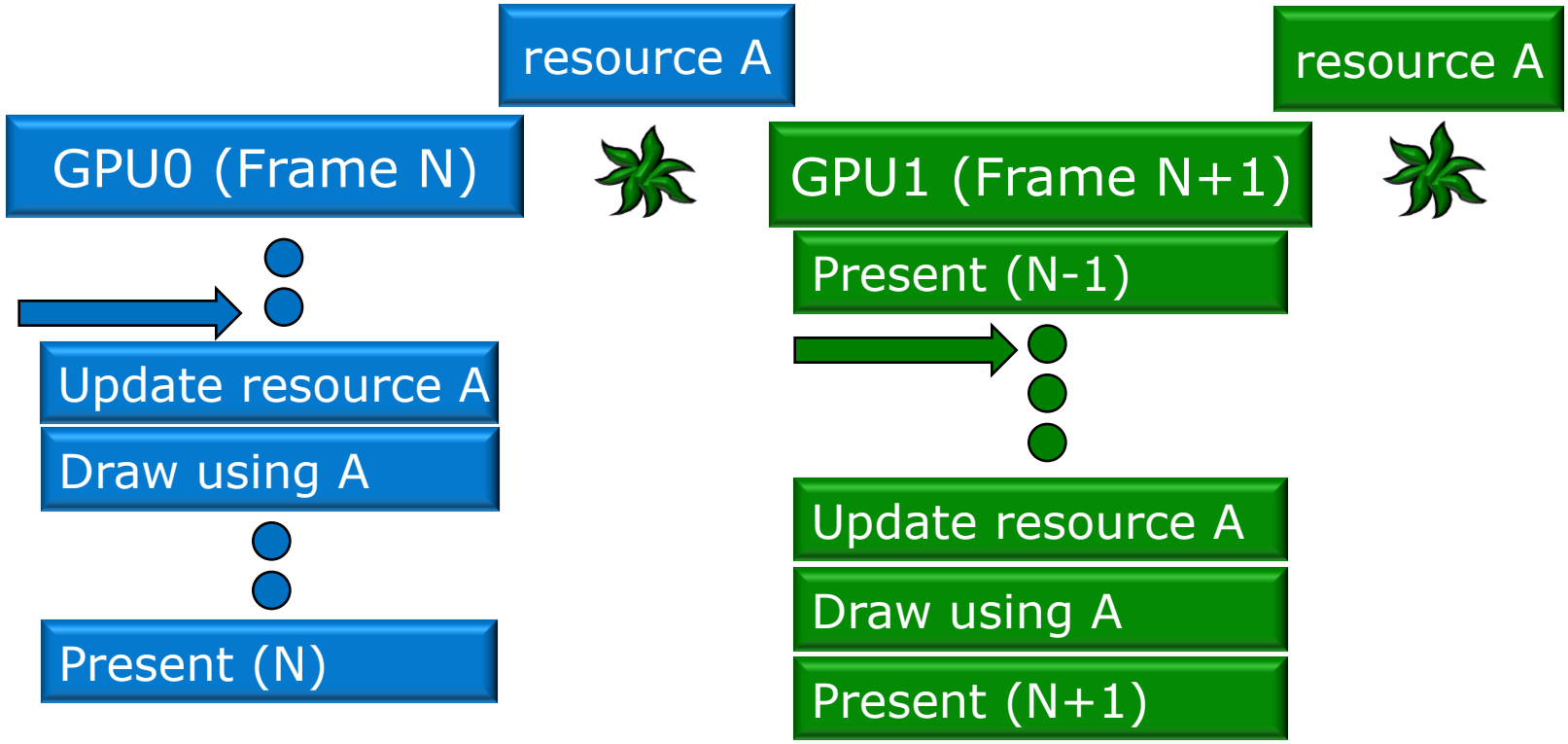

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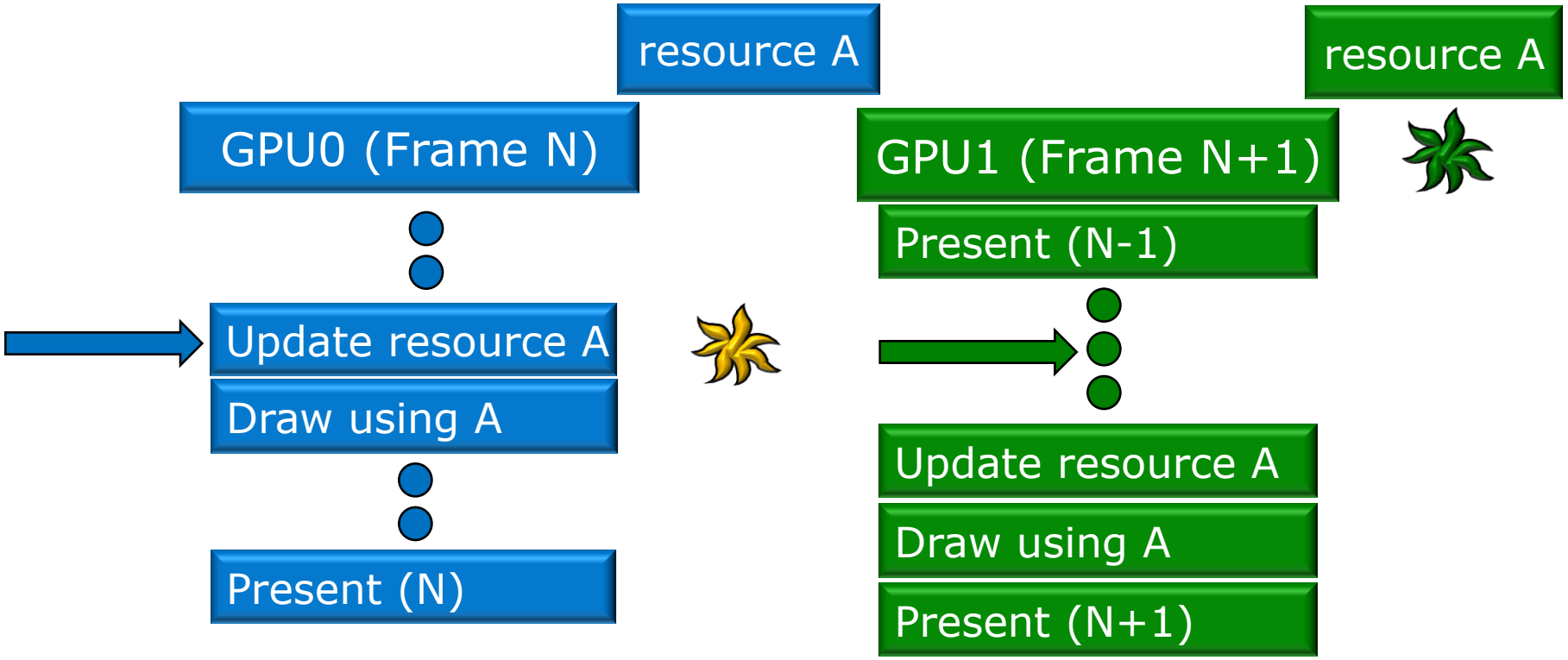

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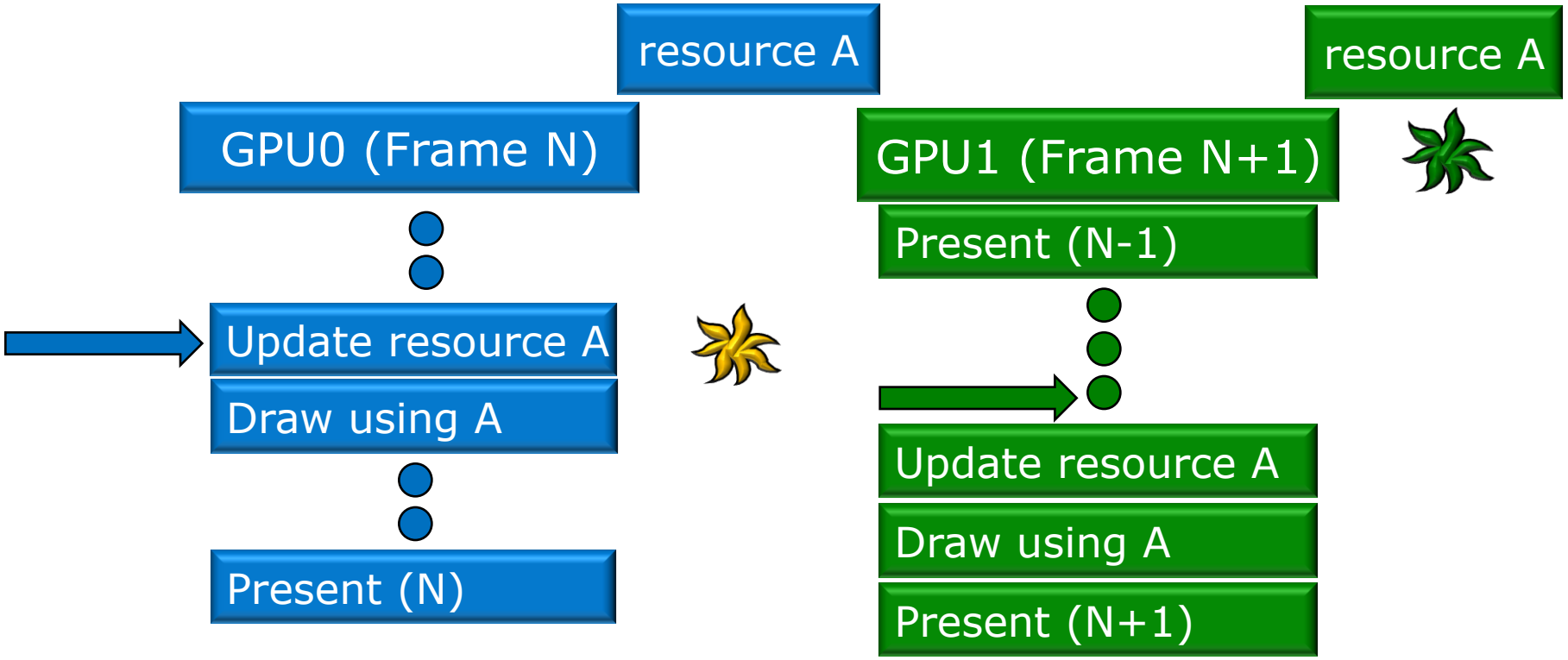

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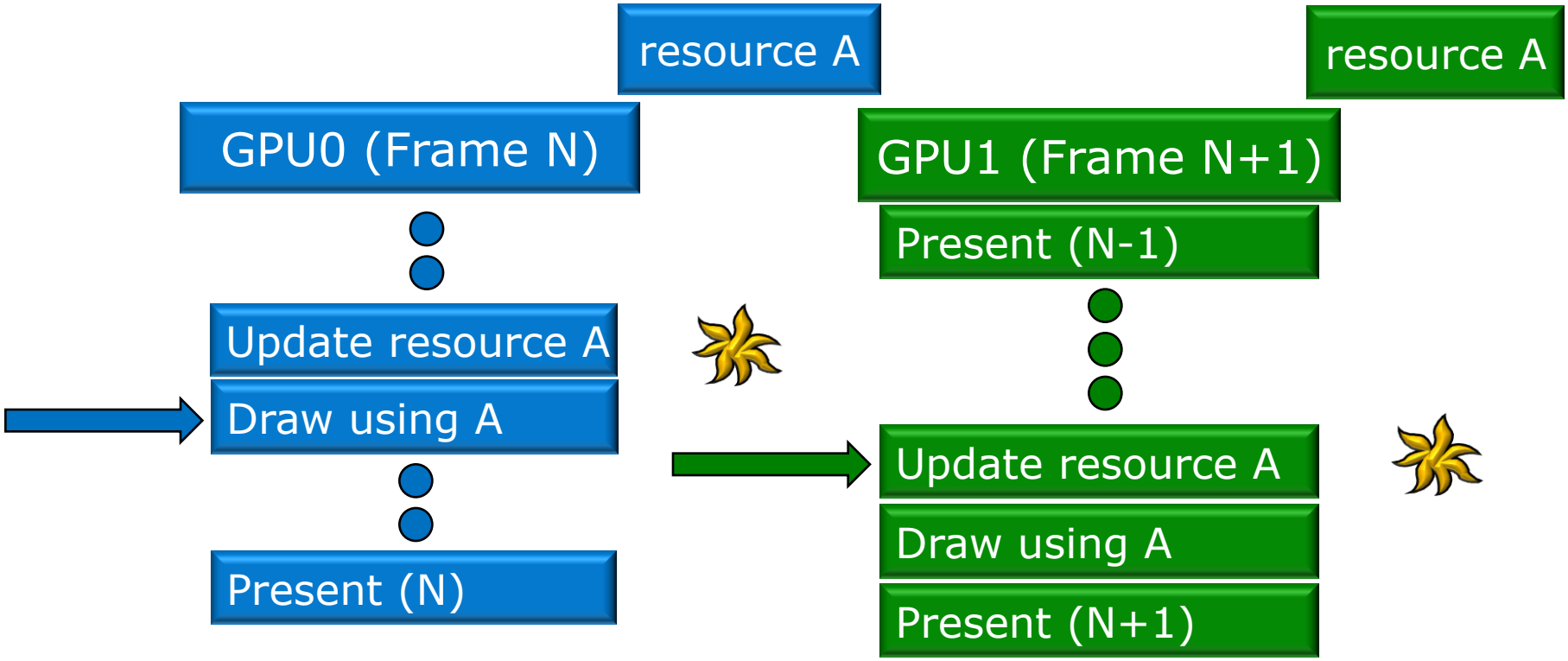

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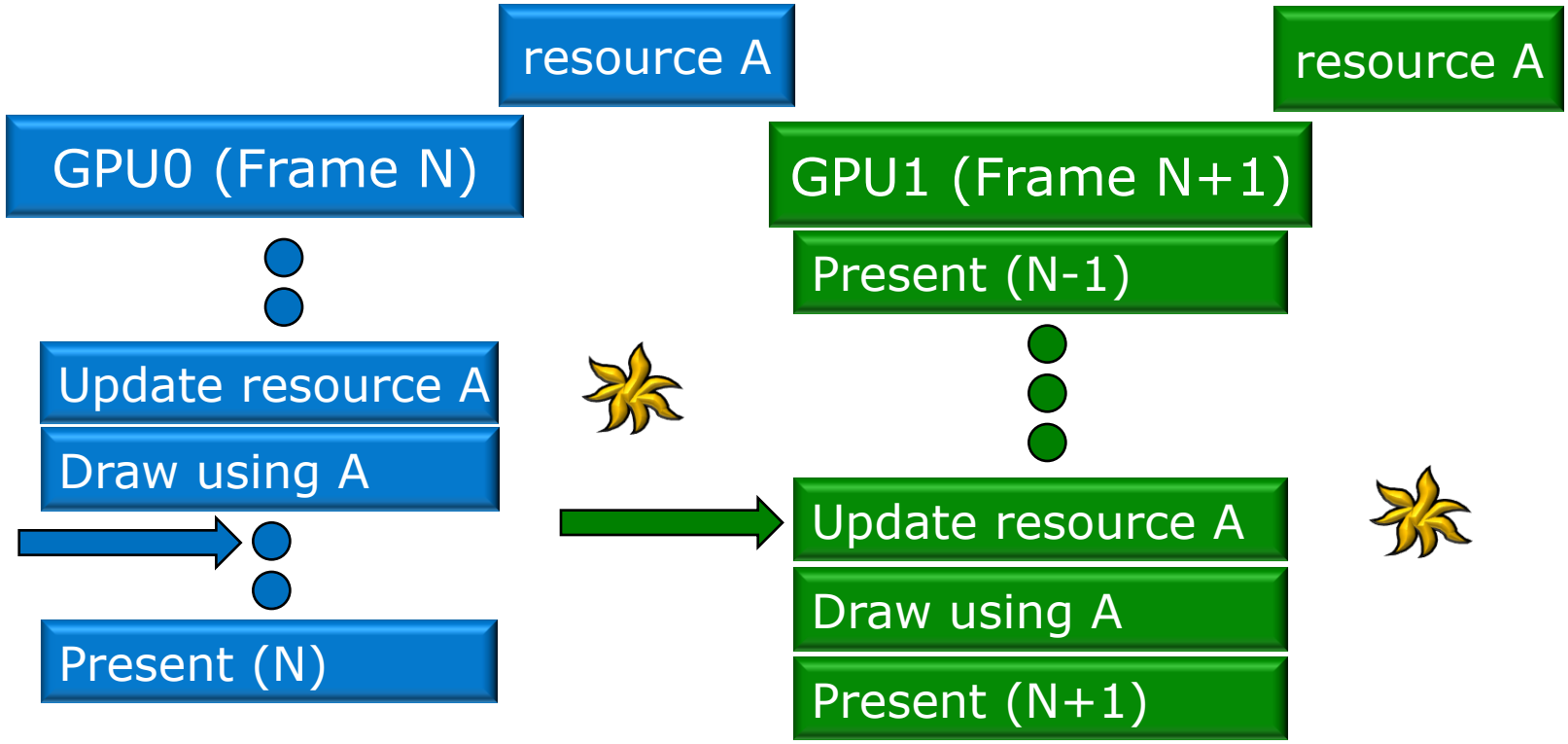

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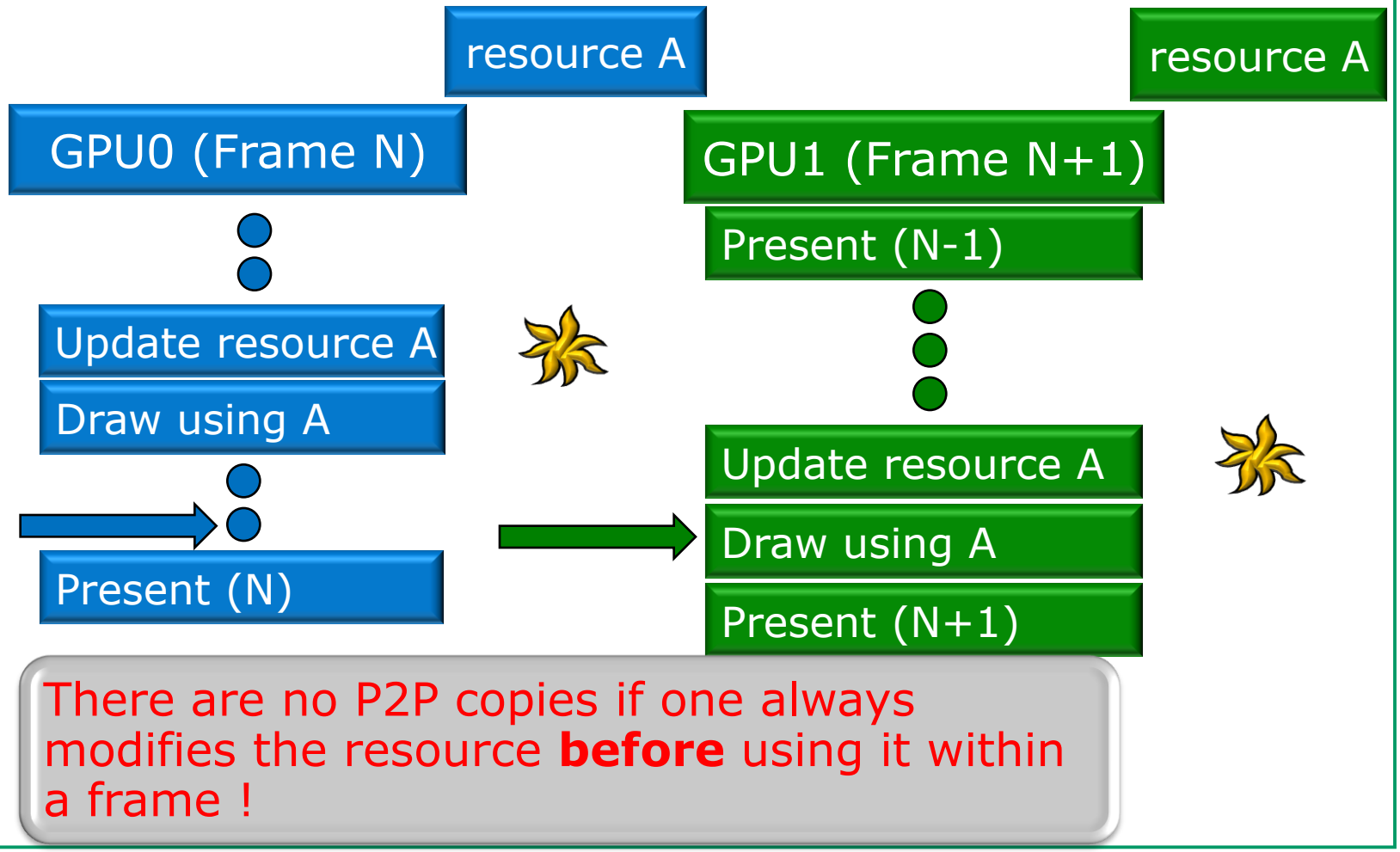

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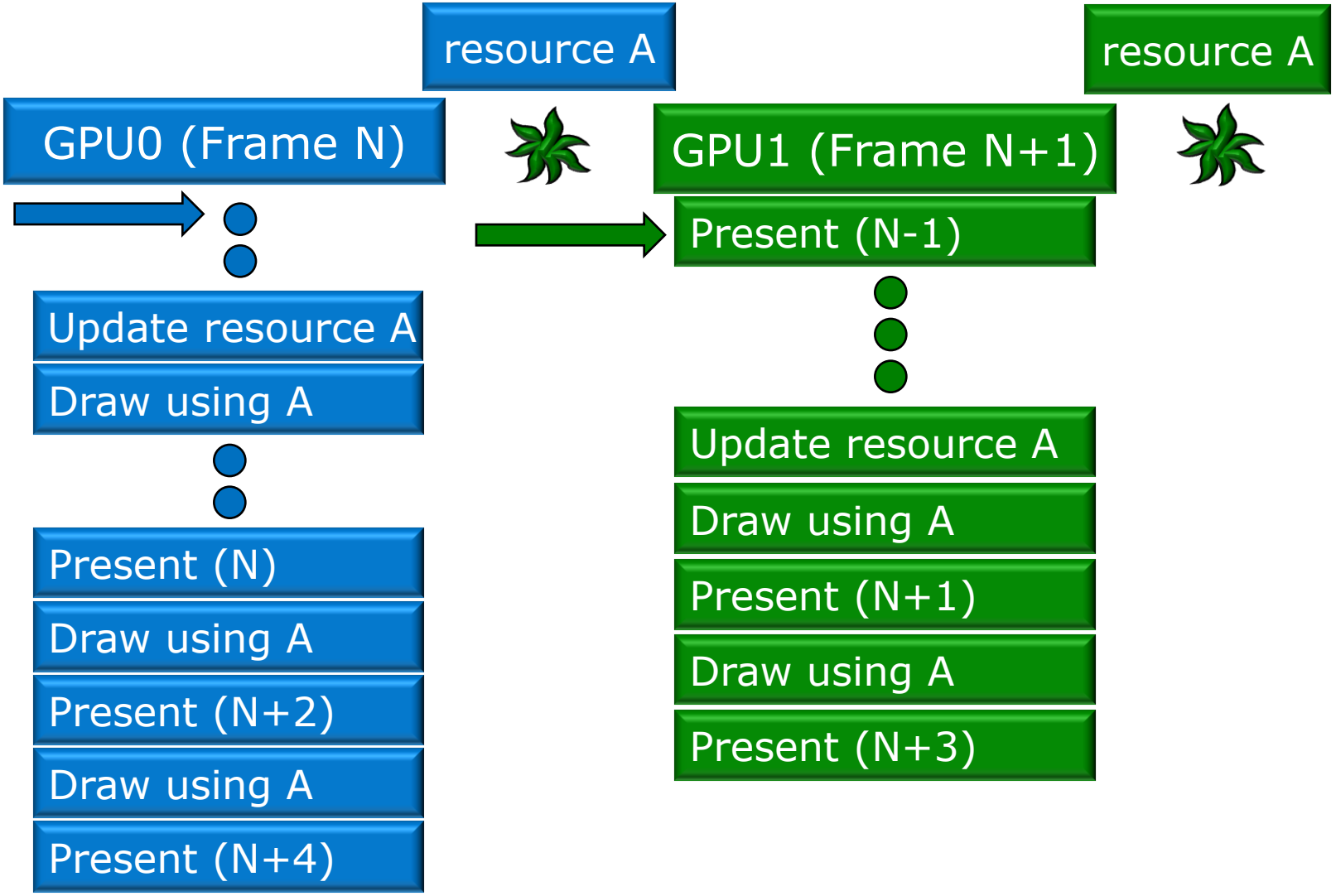

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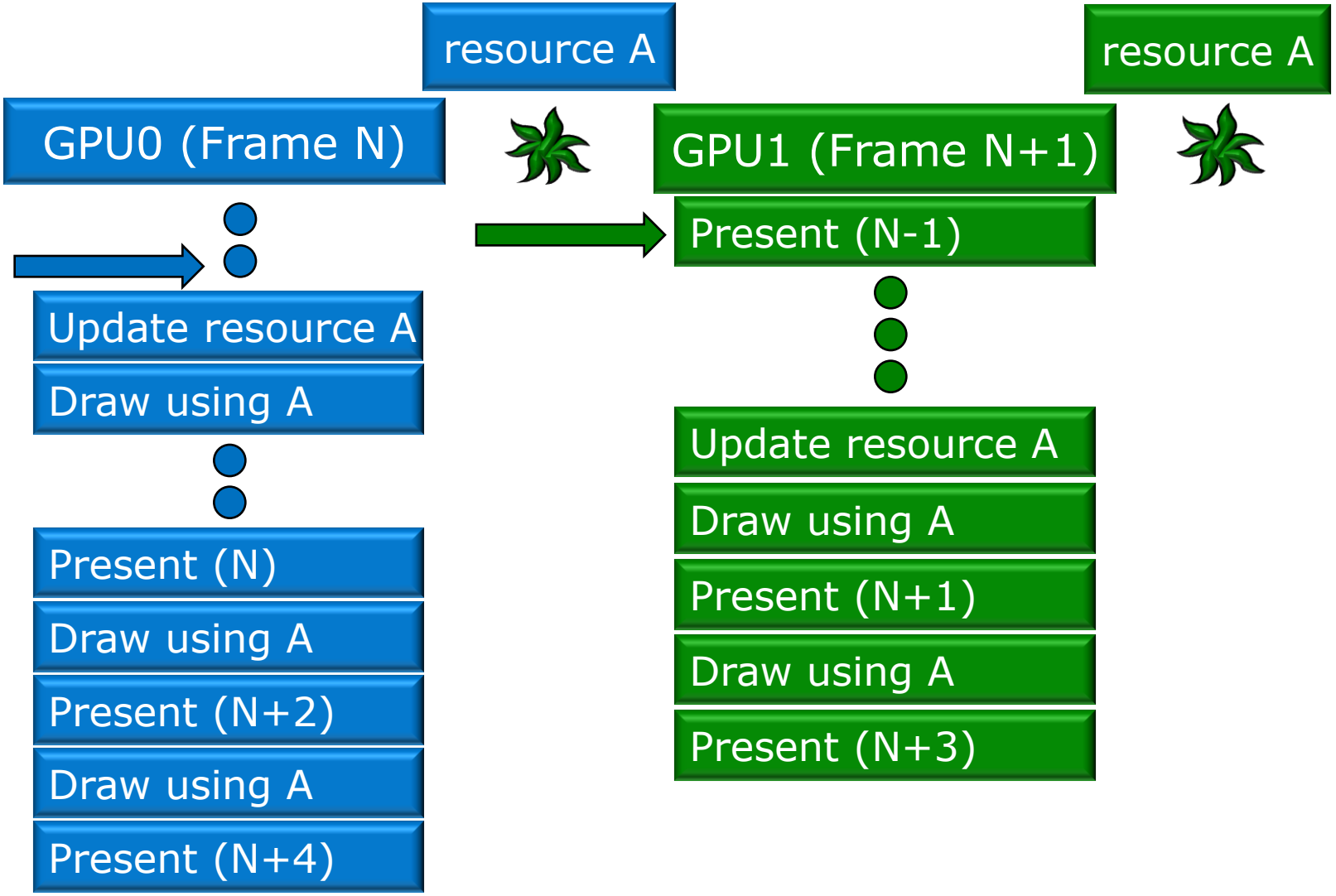

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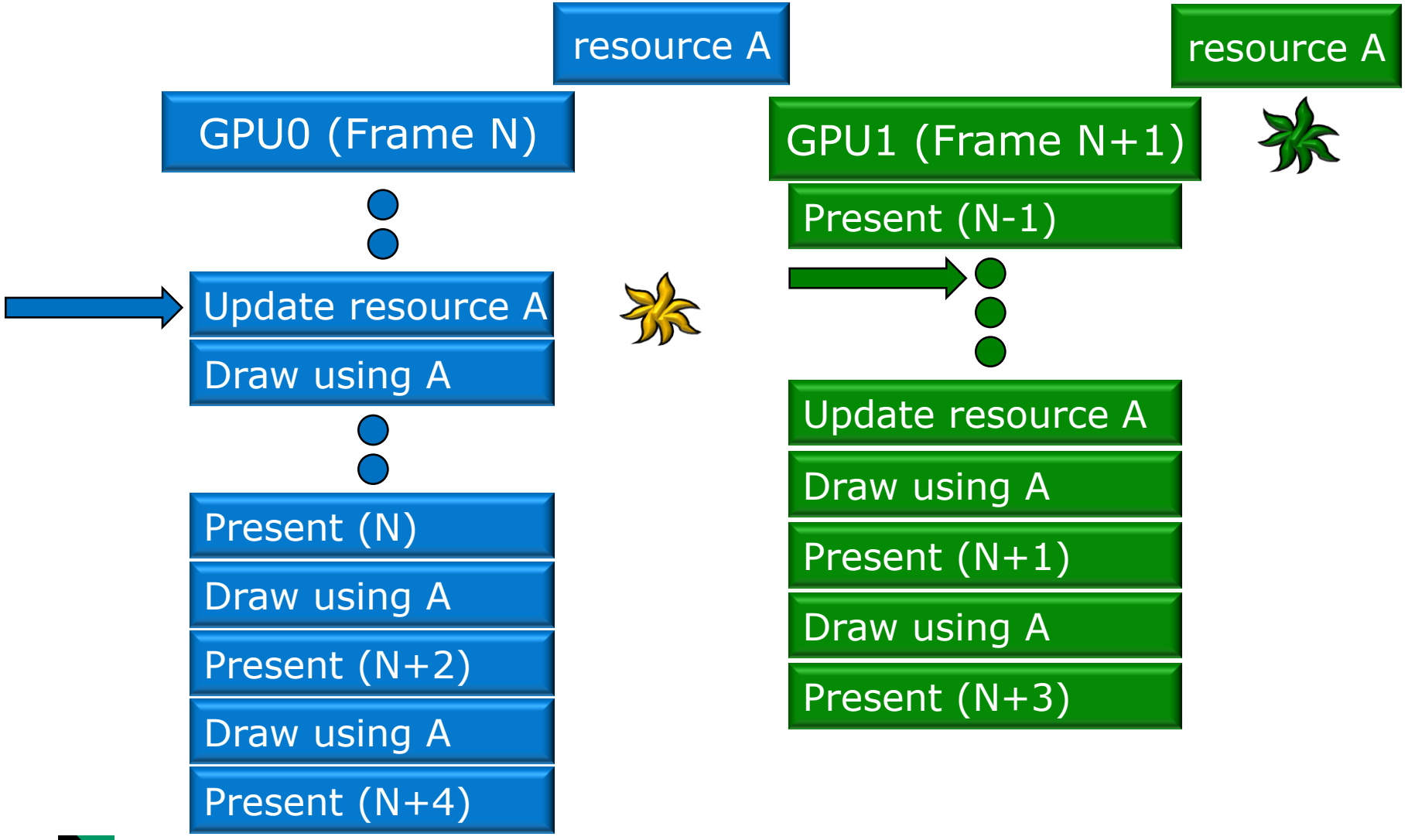

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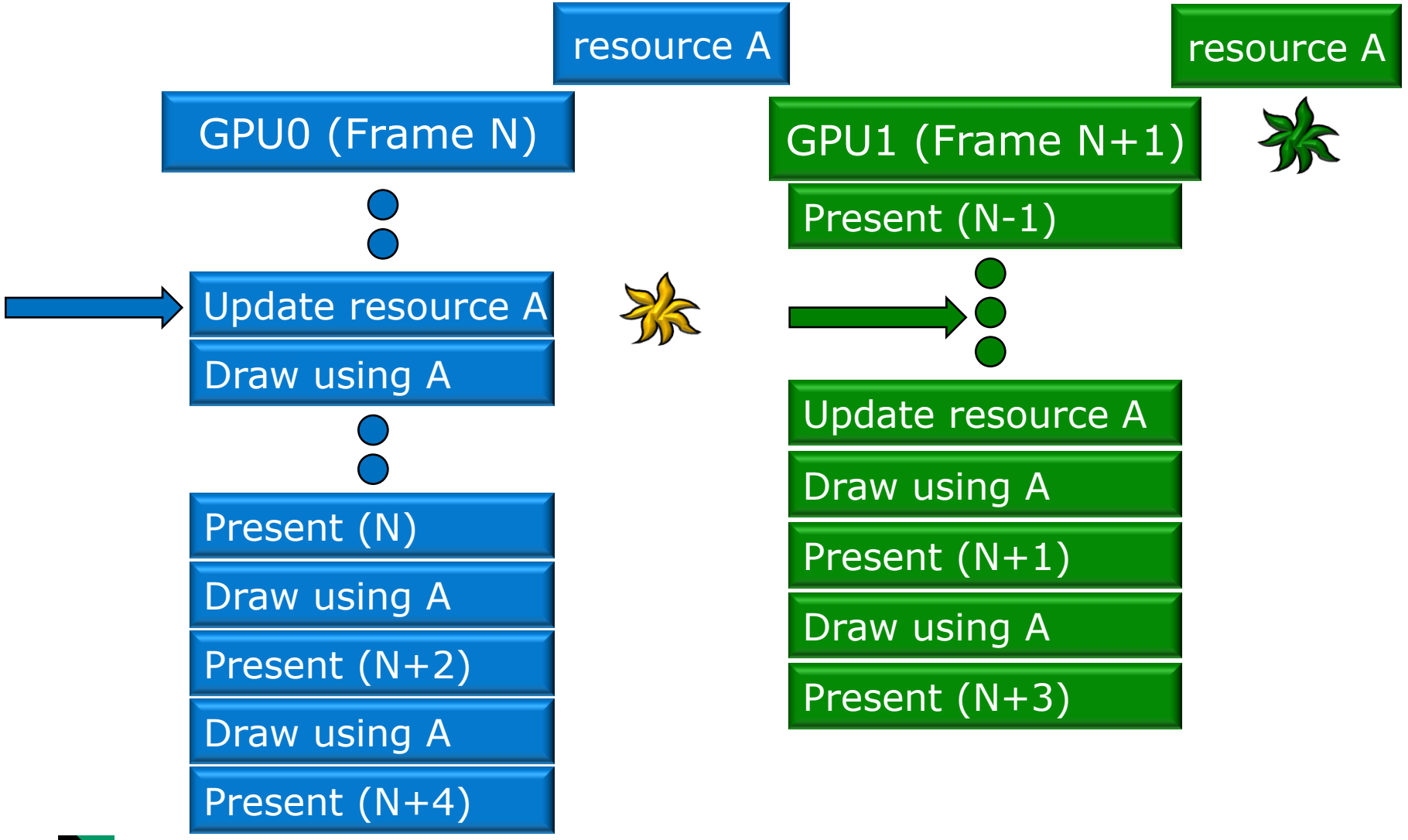

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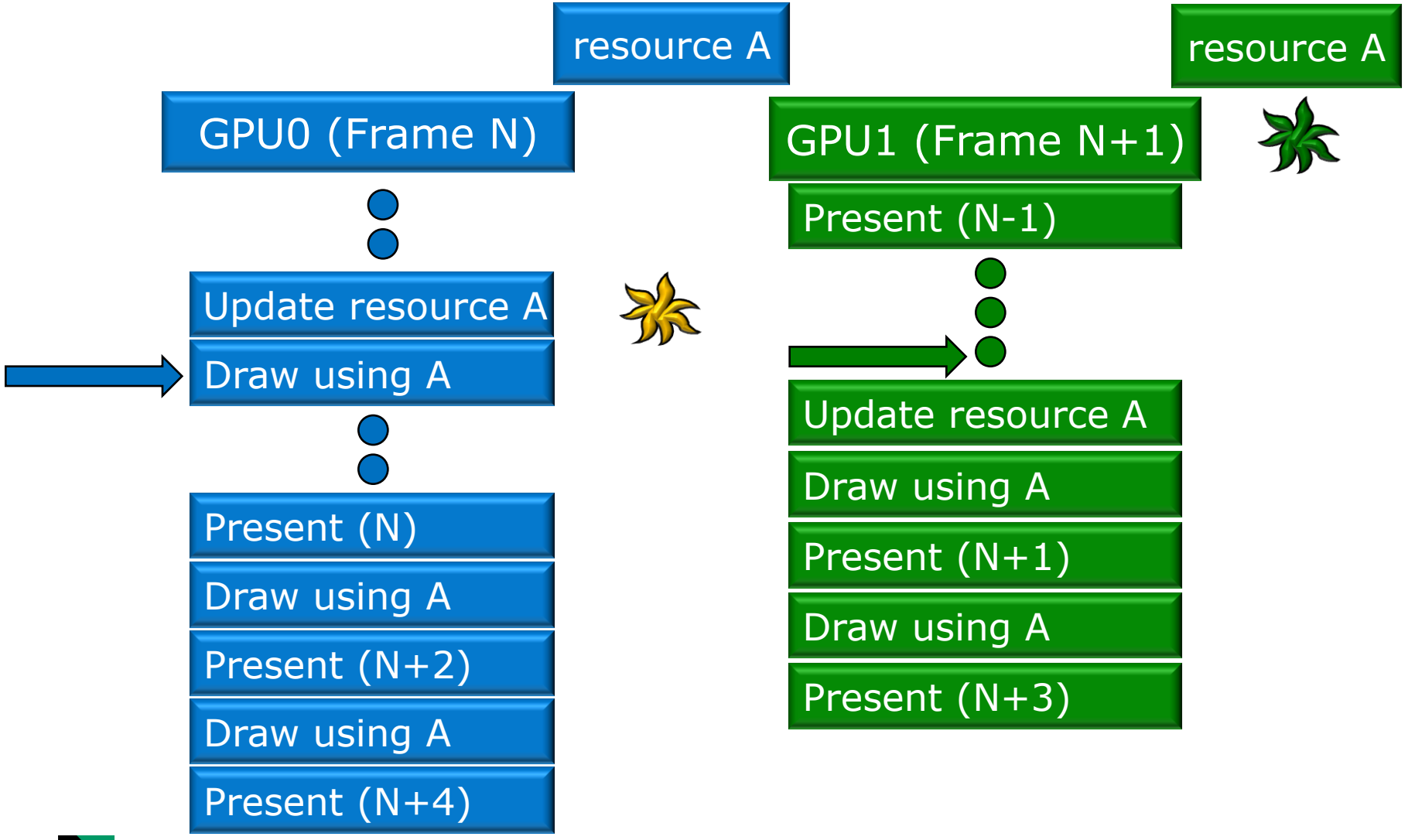

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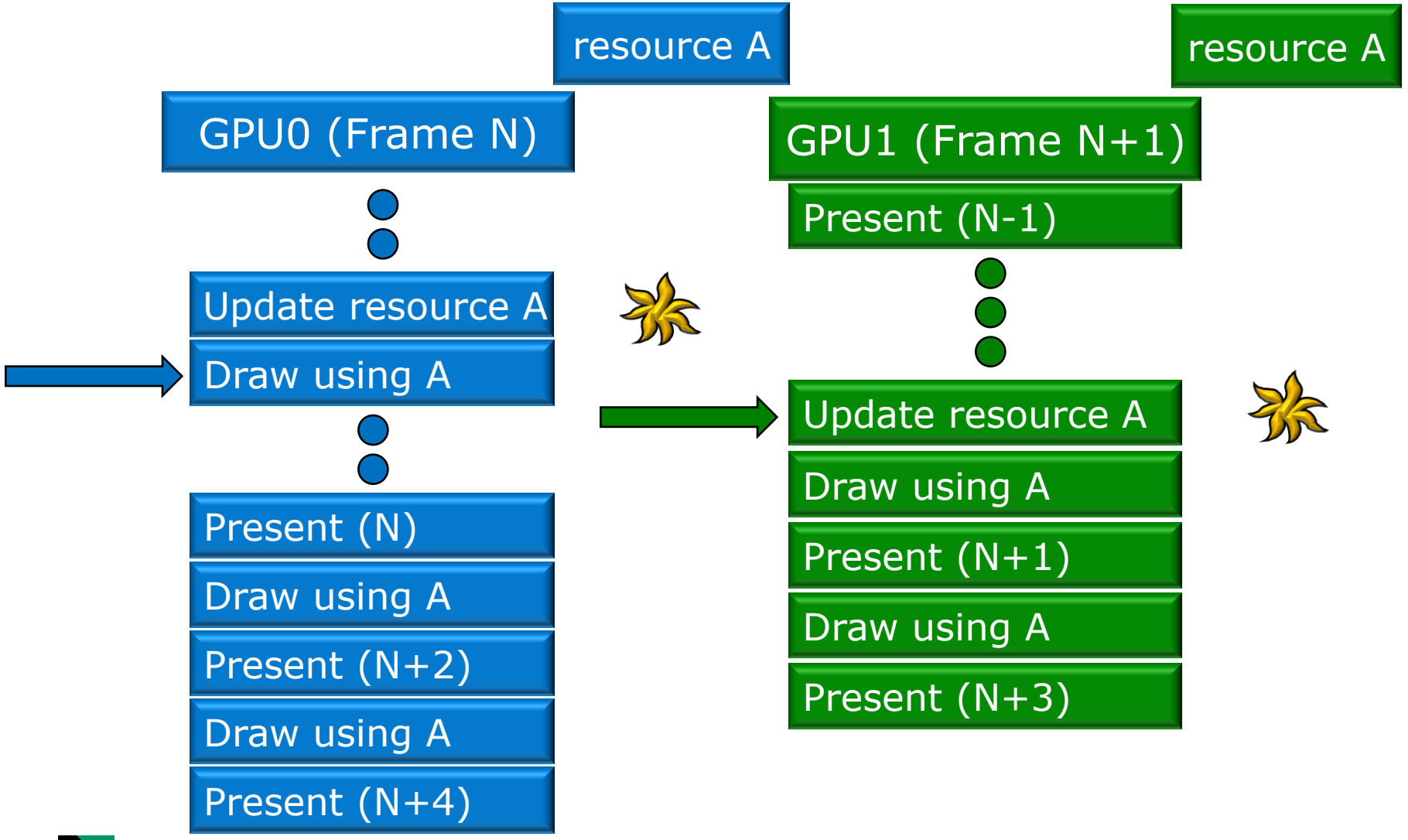

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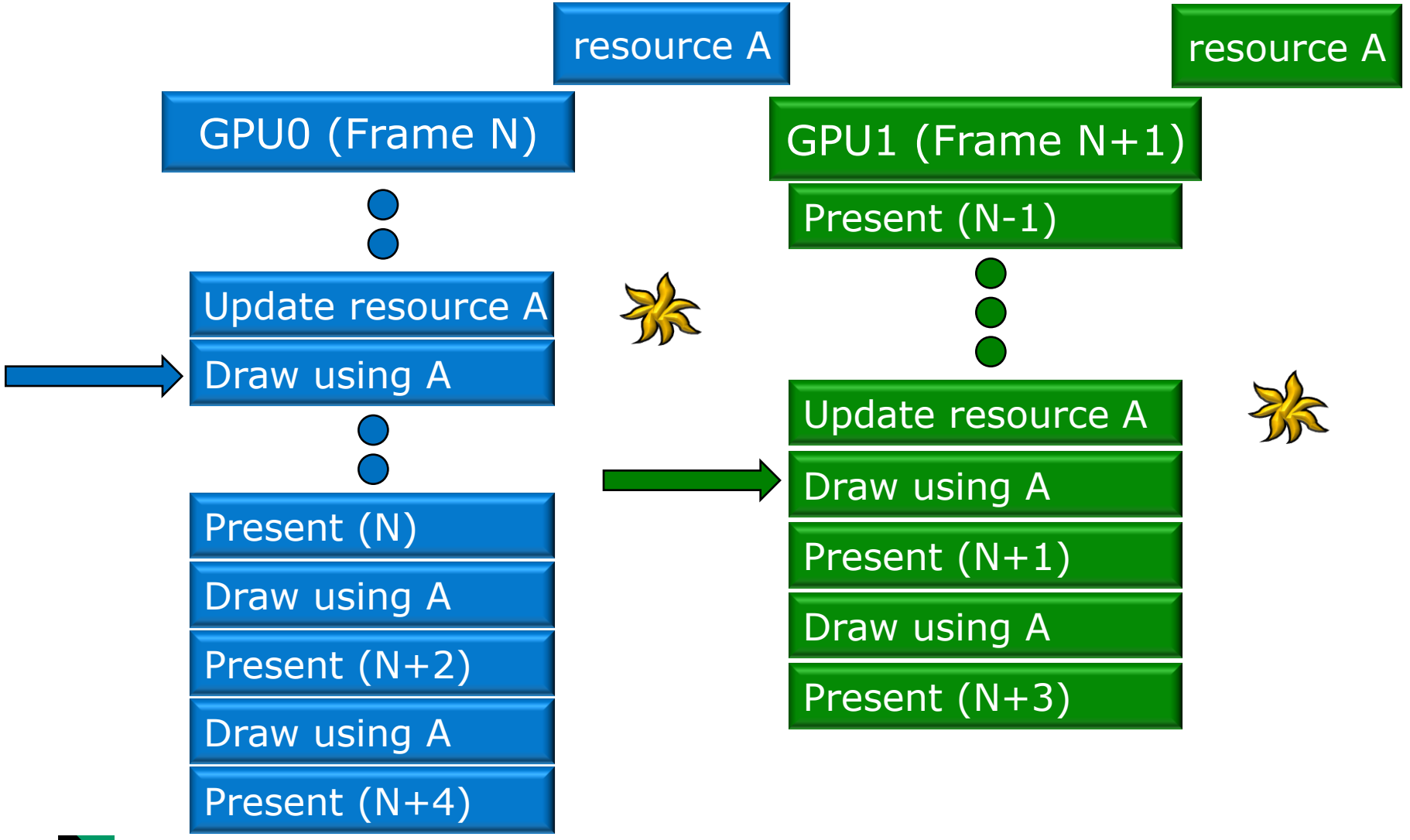

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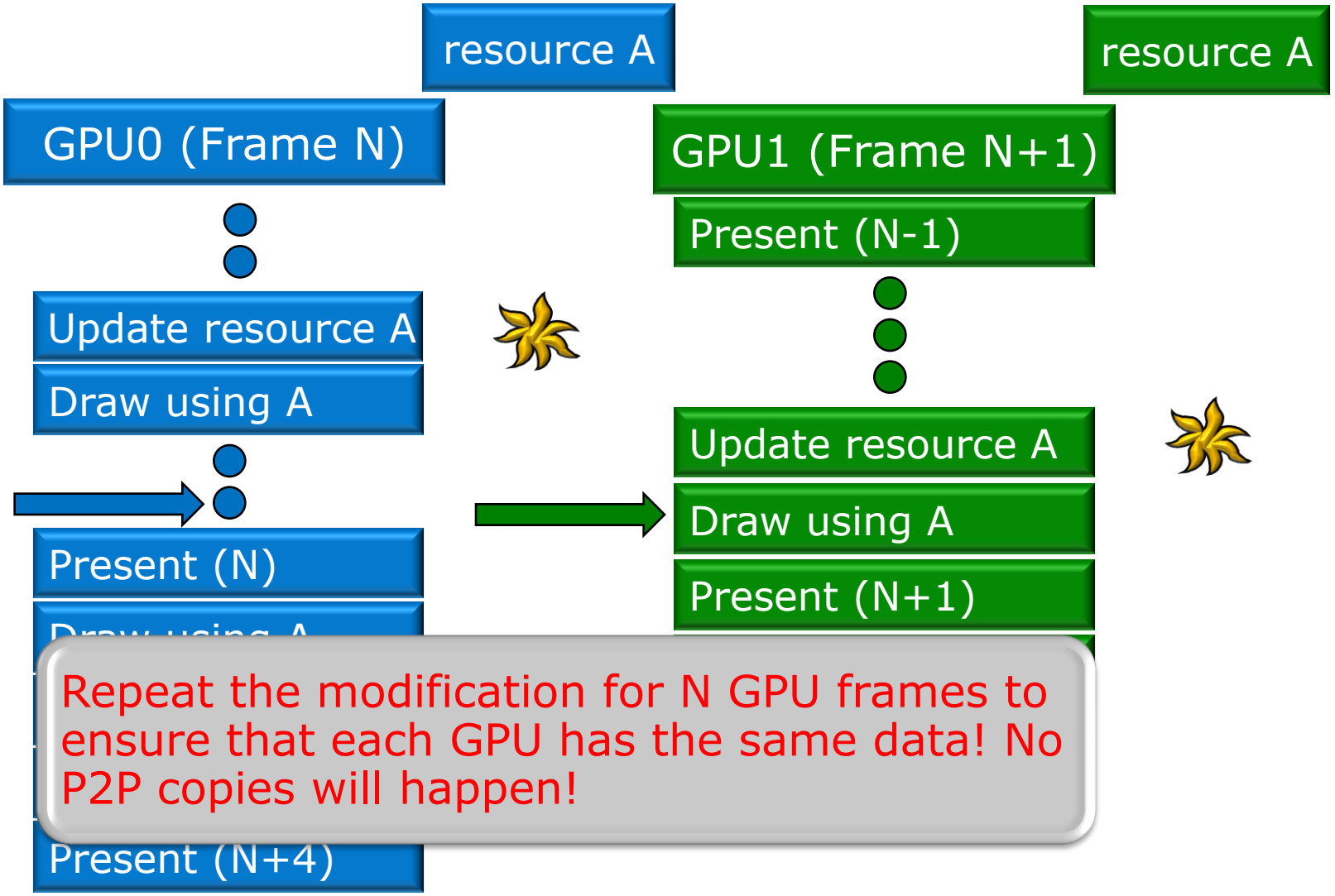

Pitfalls: In DX10 there are Other Ways to Update Resources...

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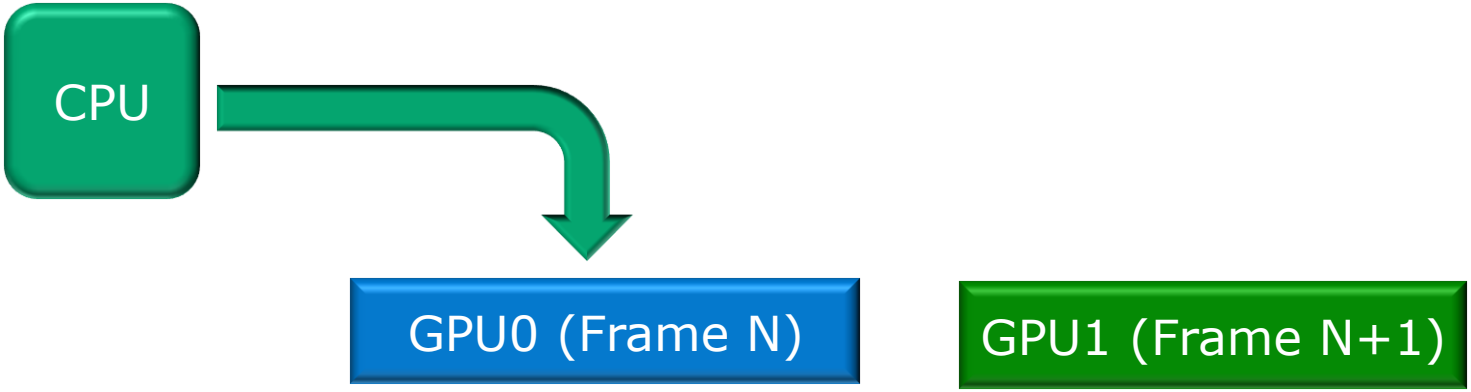
- Drawing to vertex/index buffers
- Stream Out
- CopyResource() calls
- CopySubresourceRegion() calls
- GenerateMips() calls
- ResolveSubresource() calls

Pitfall: Waiting on Queries



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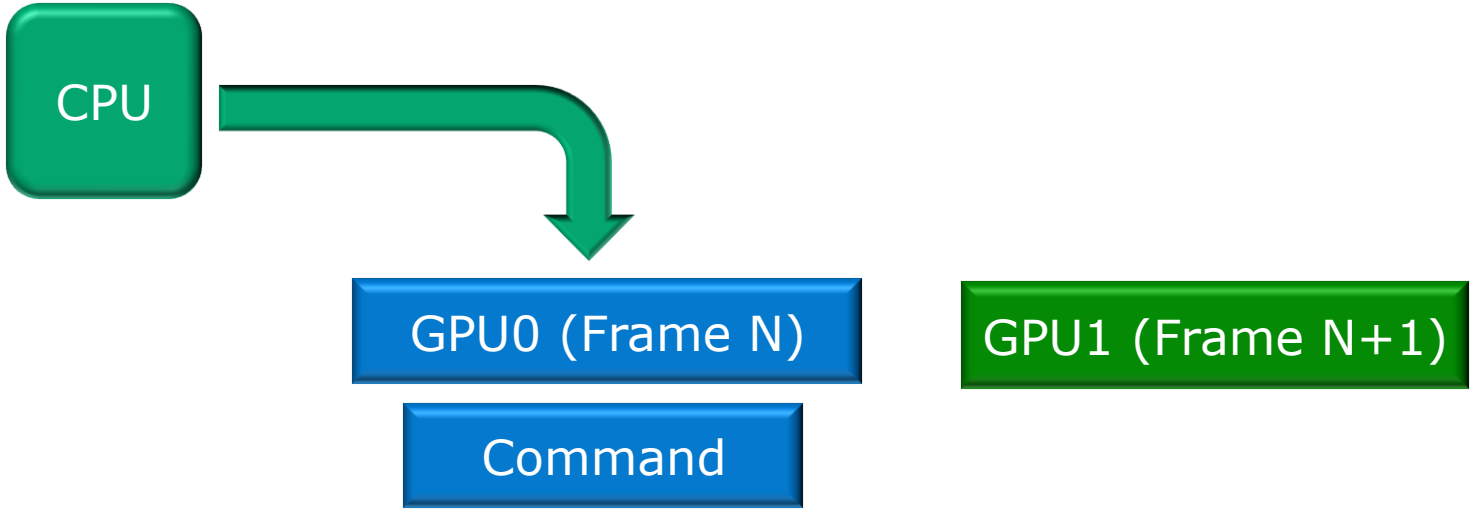

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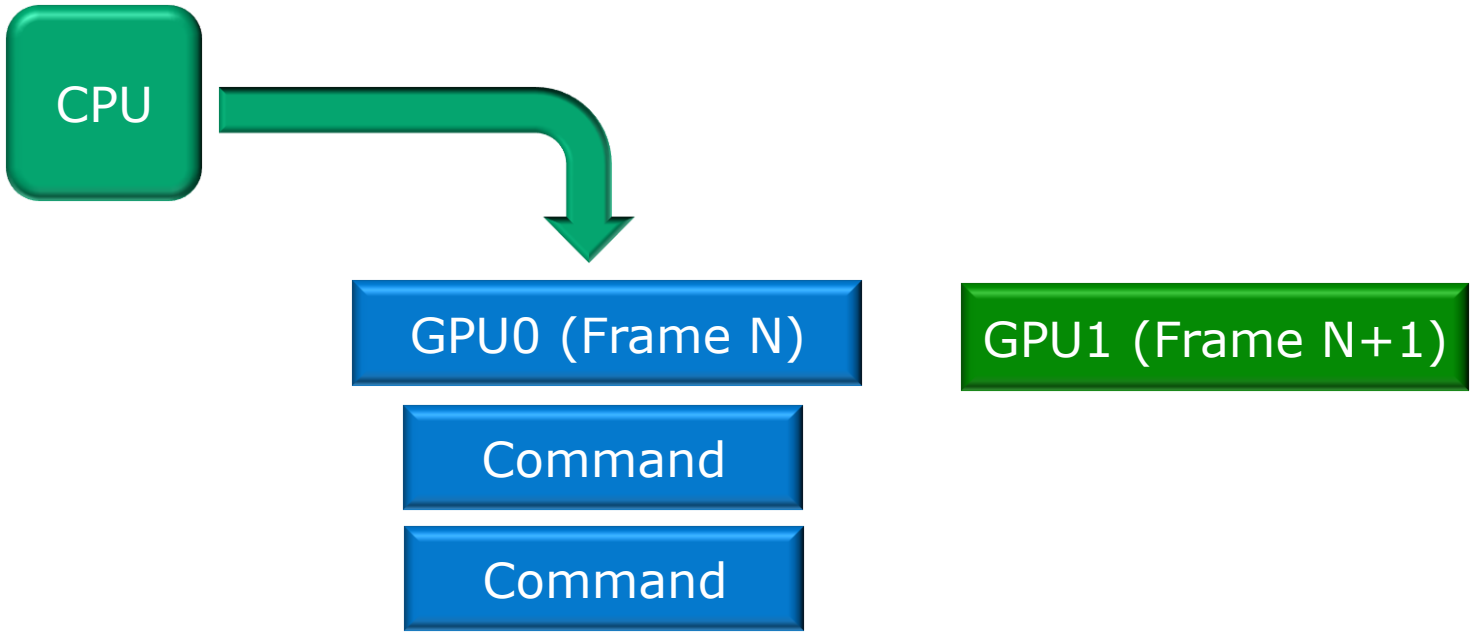

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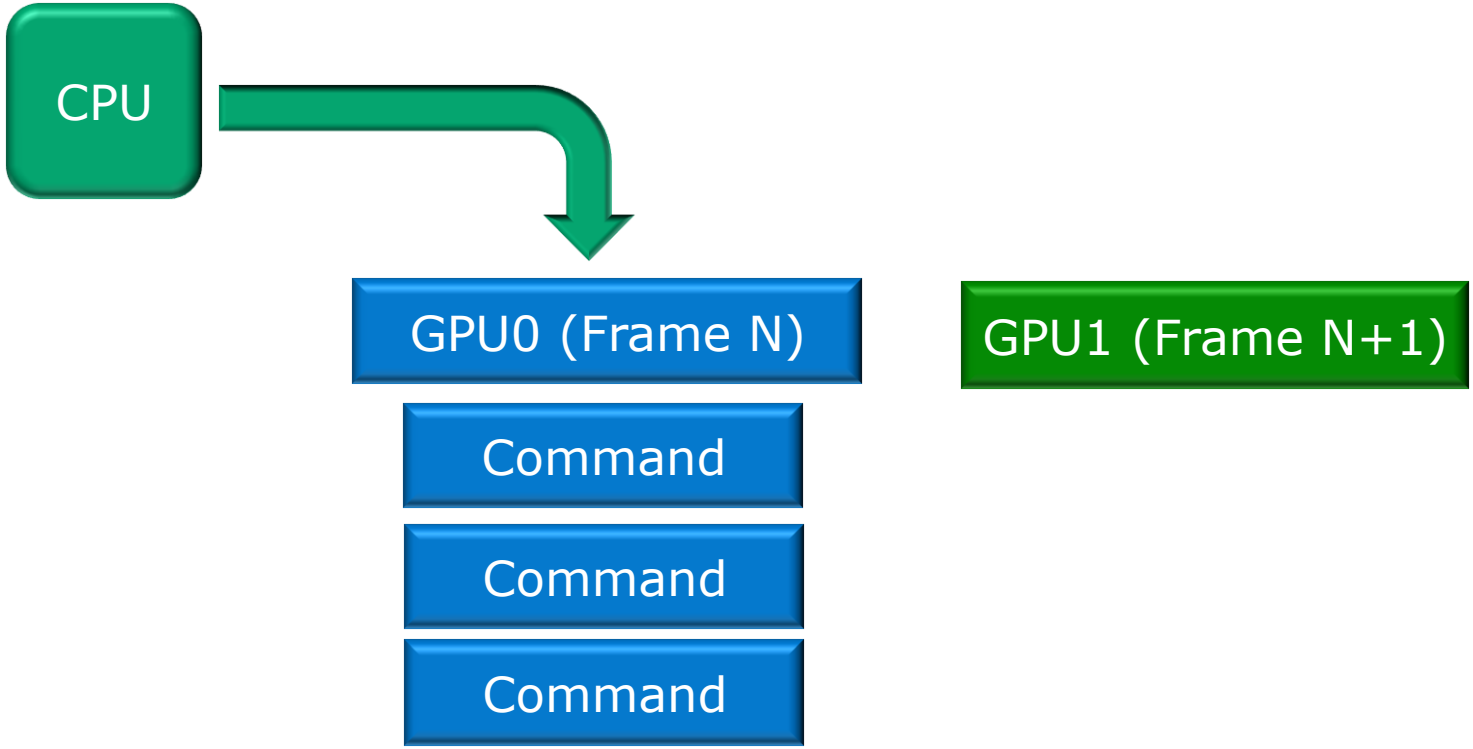
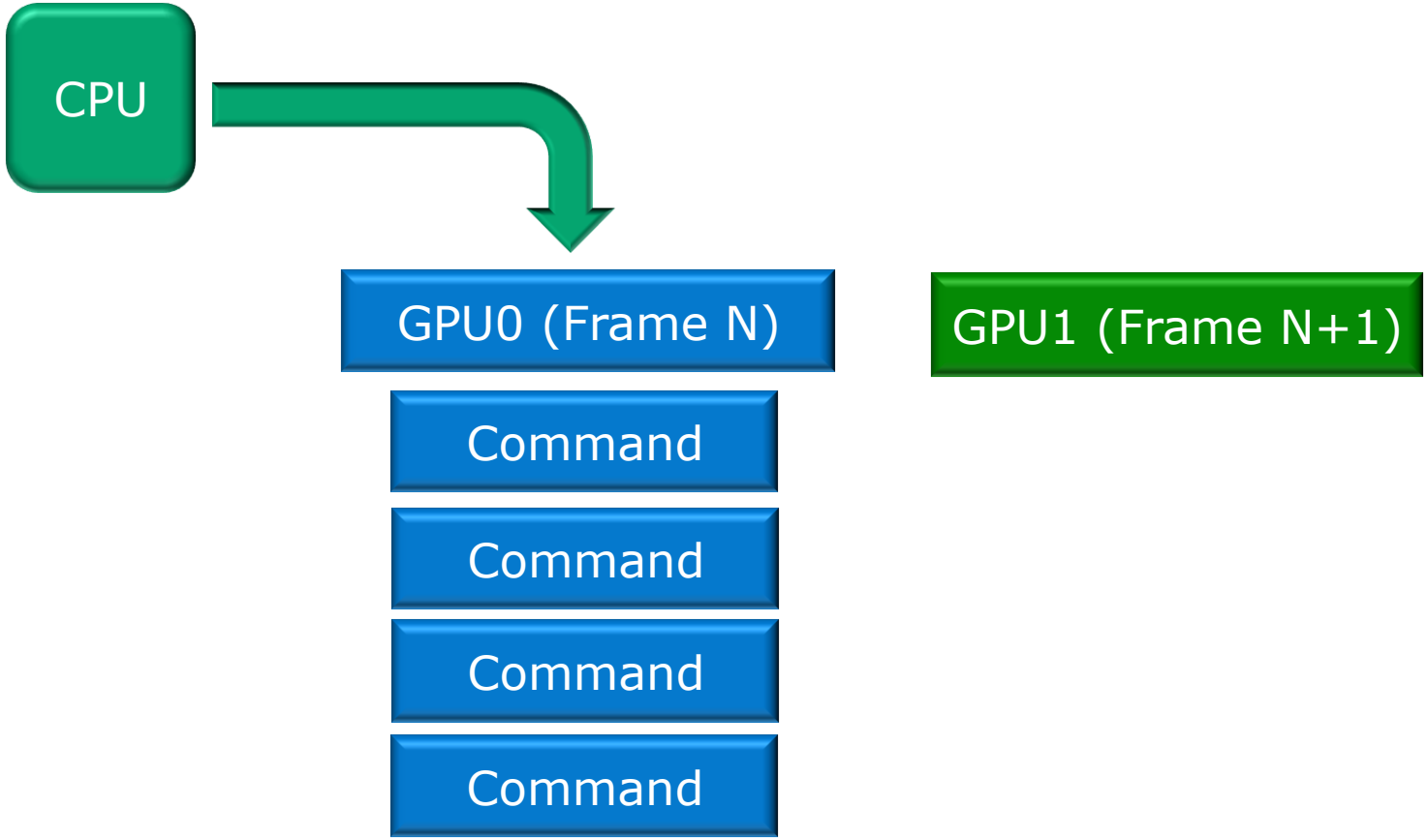
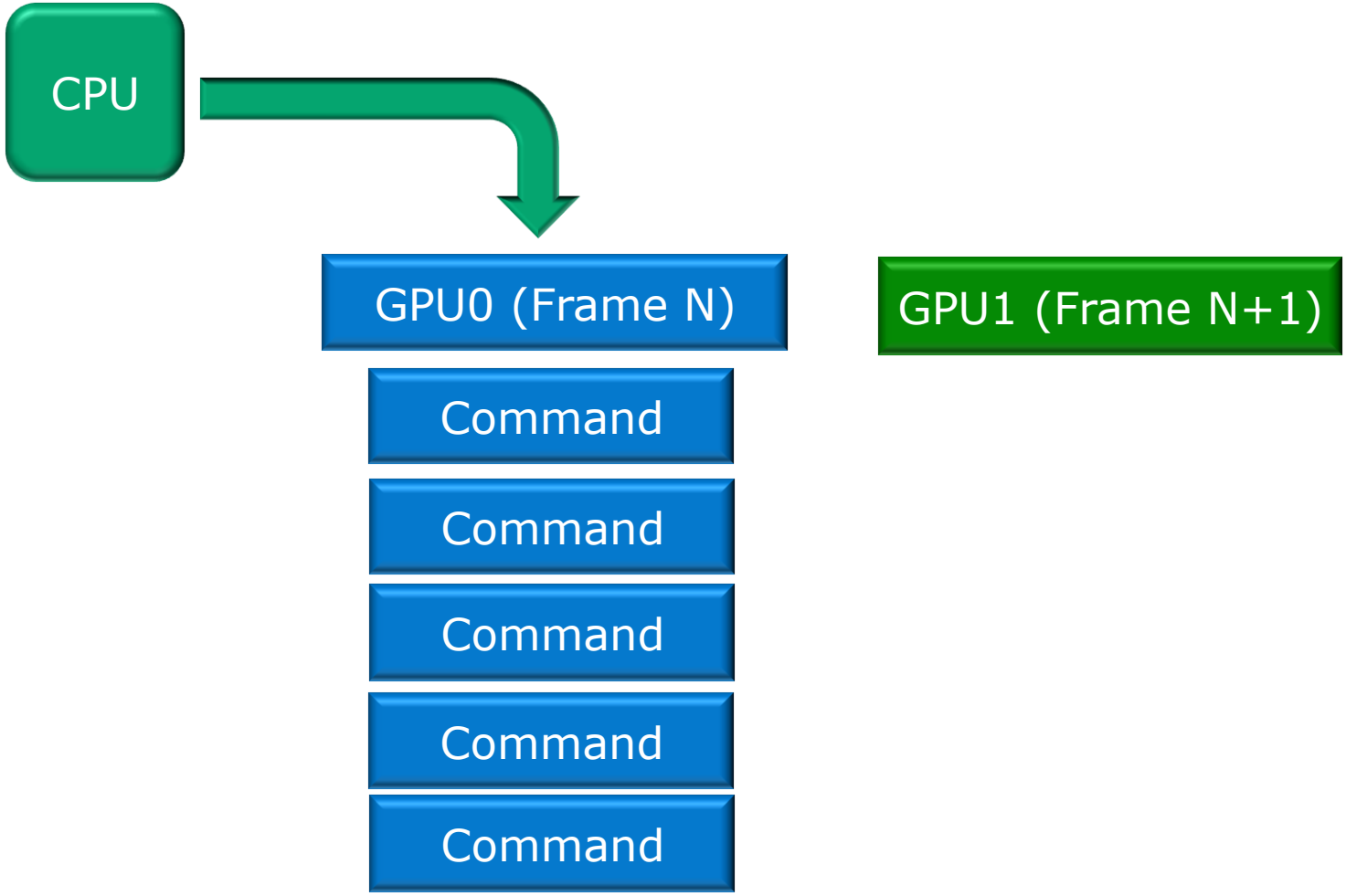


Pitfall: Waiting on Queries



Pitfall: Waiting on Queries



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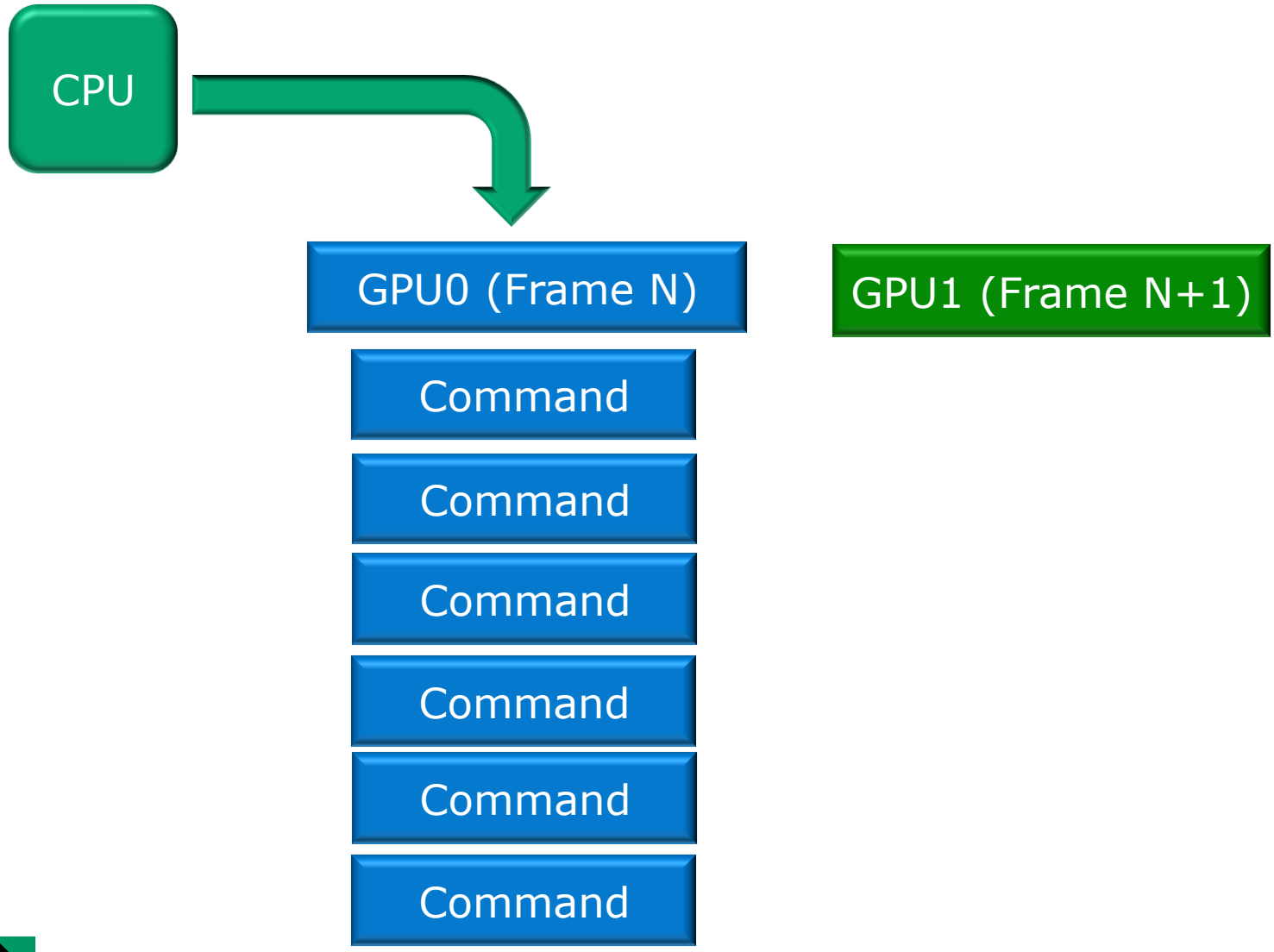
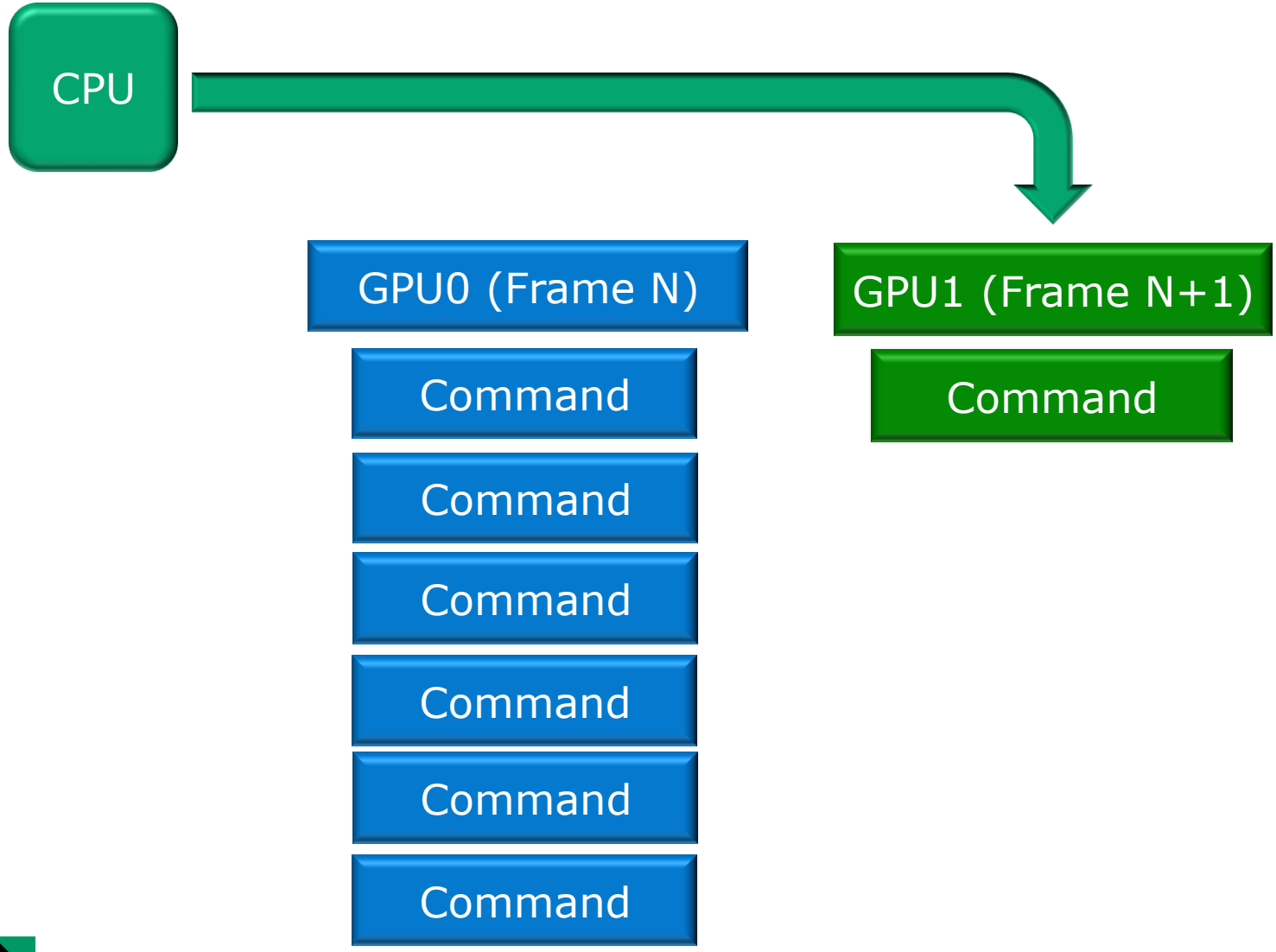


Pitfall: Waiting on Queries



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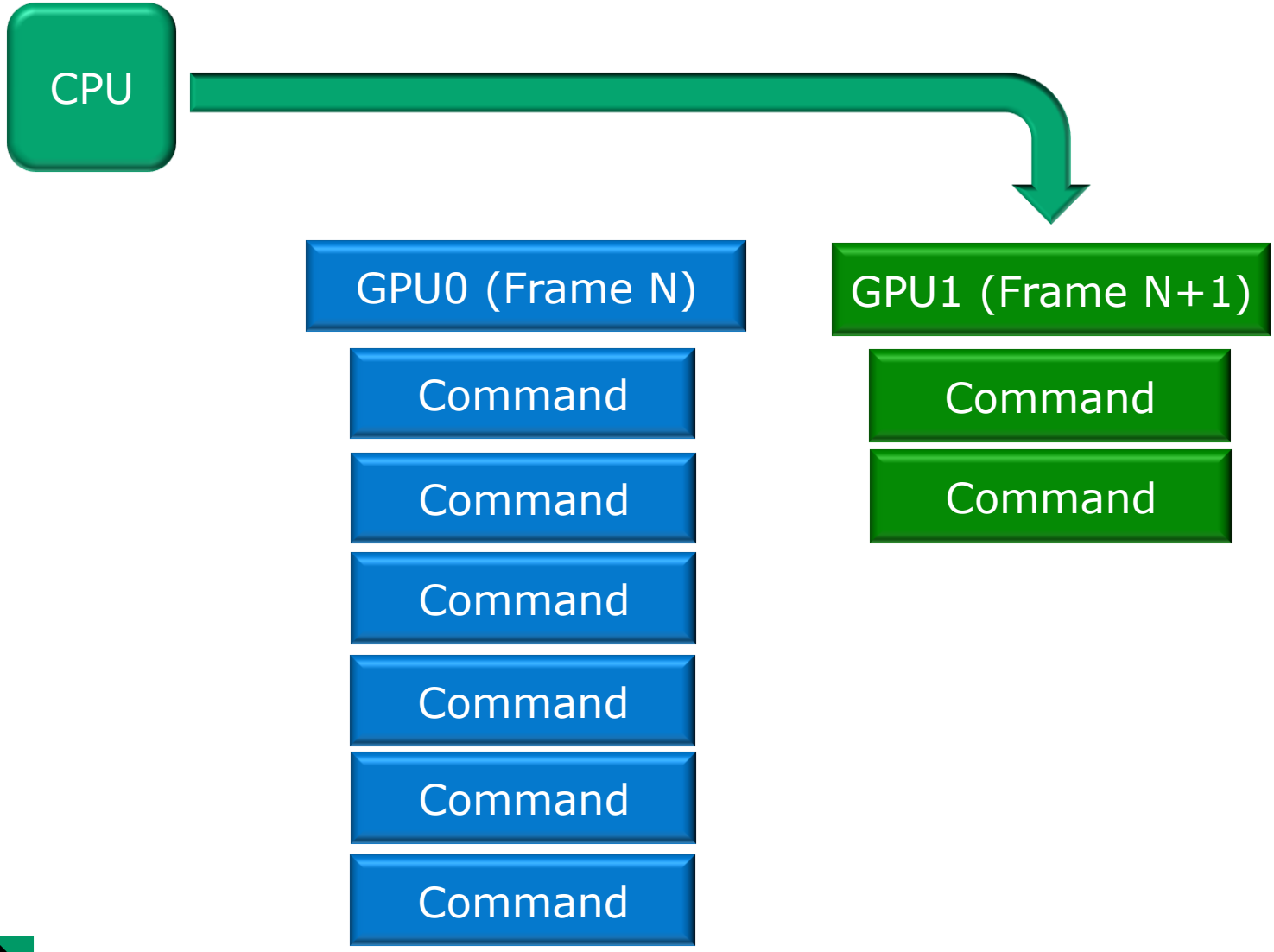

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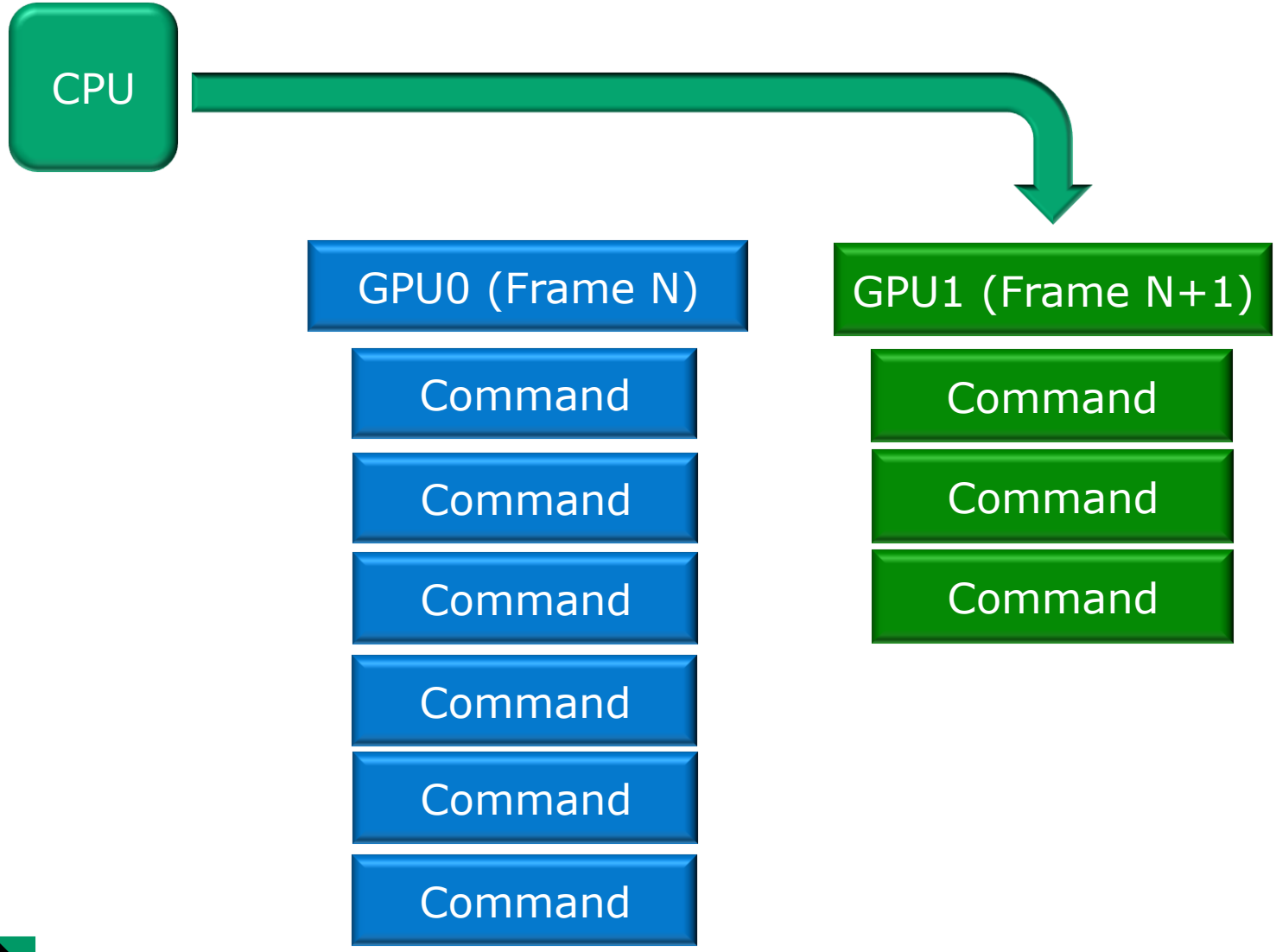

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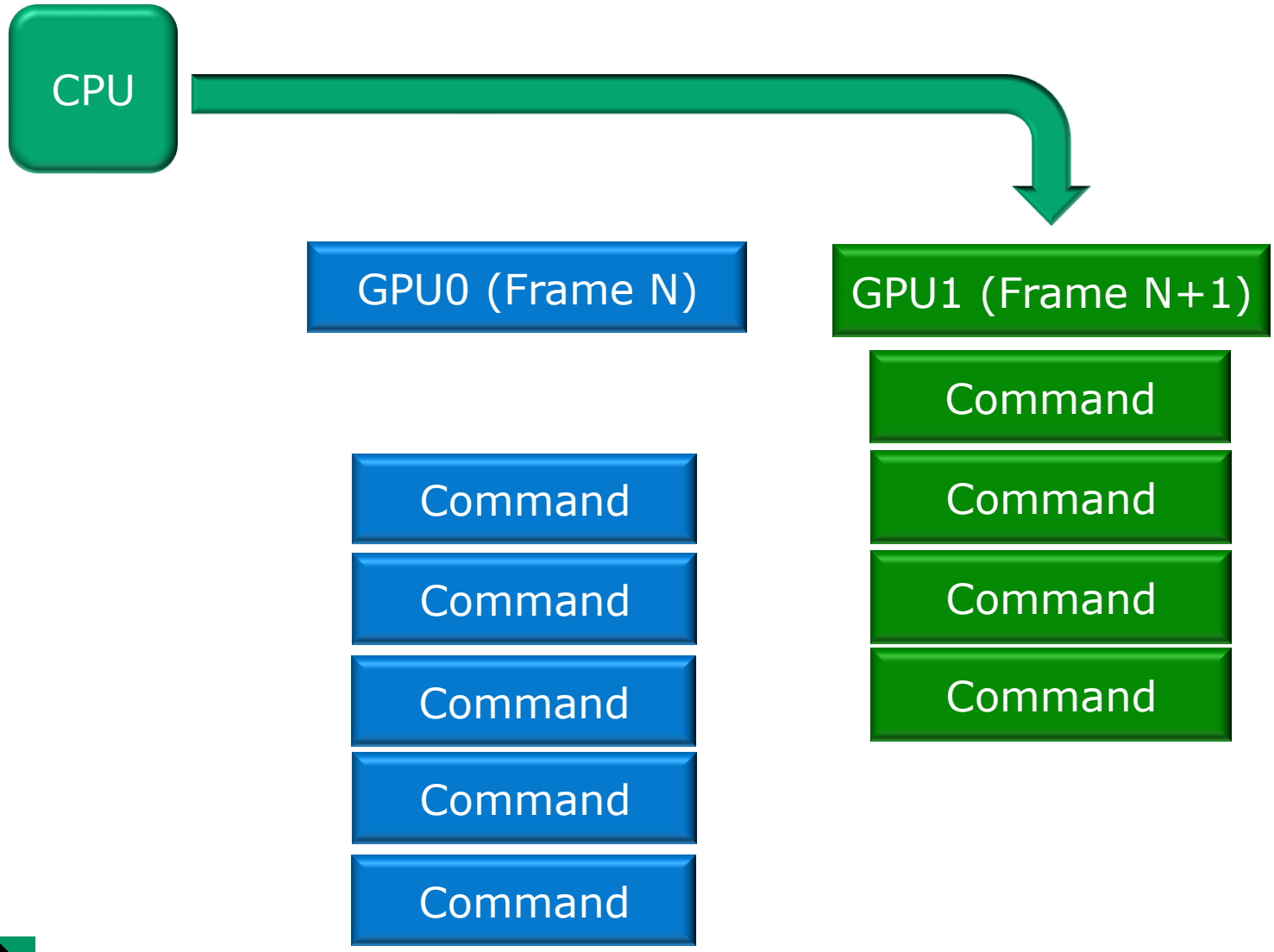
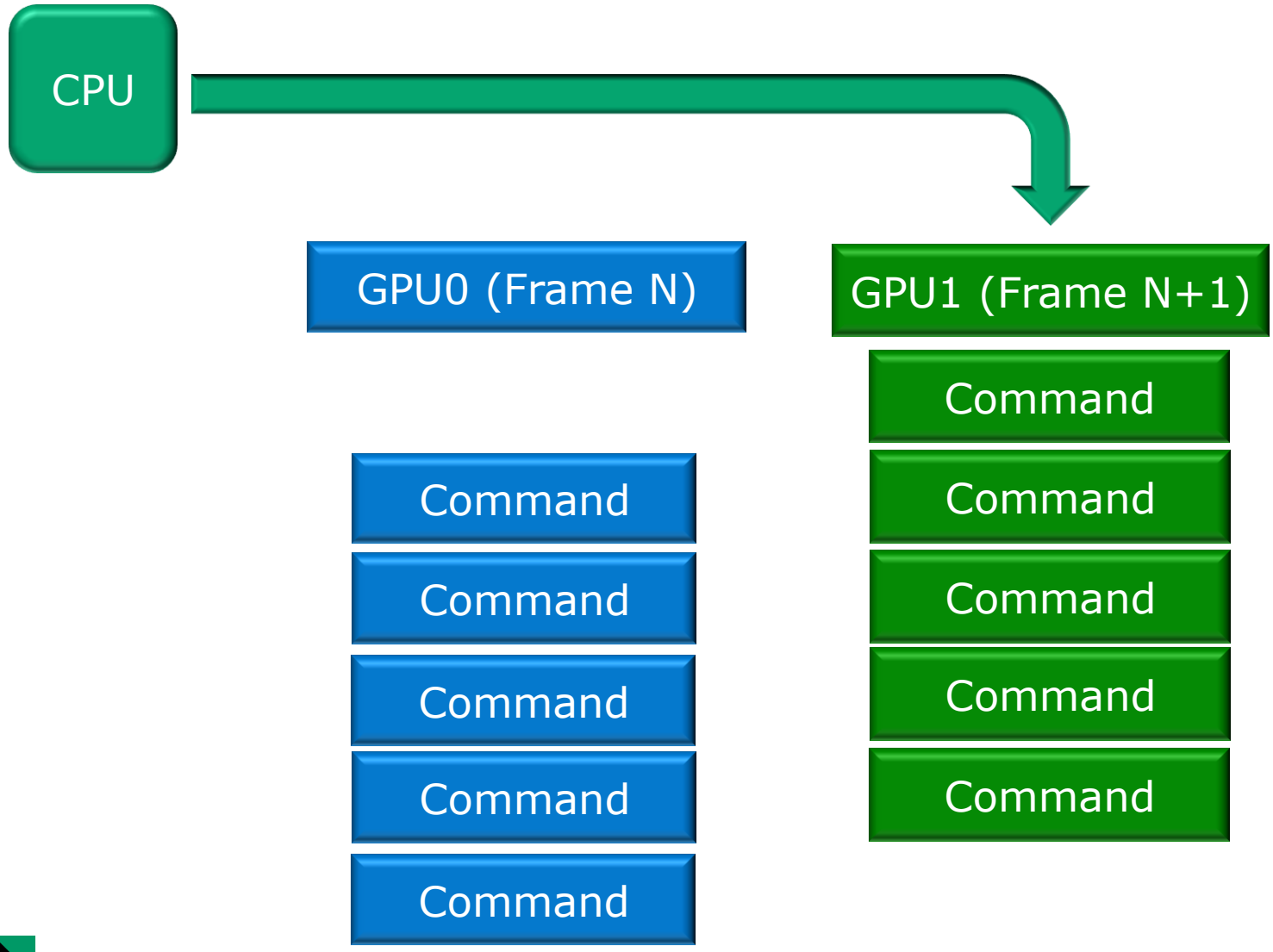


Pitfall: Waiting on Queries



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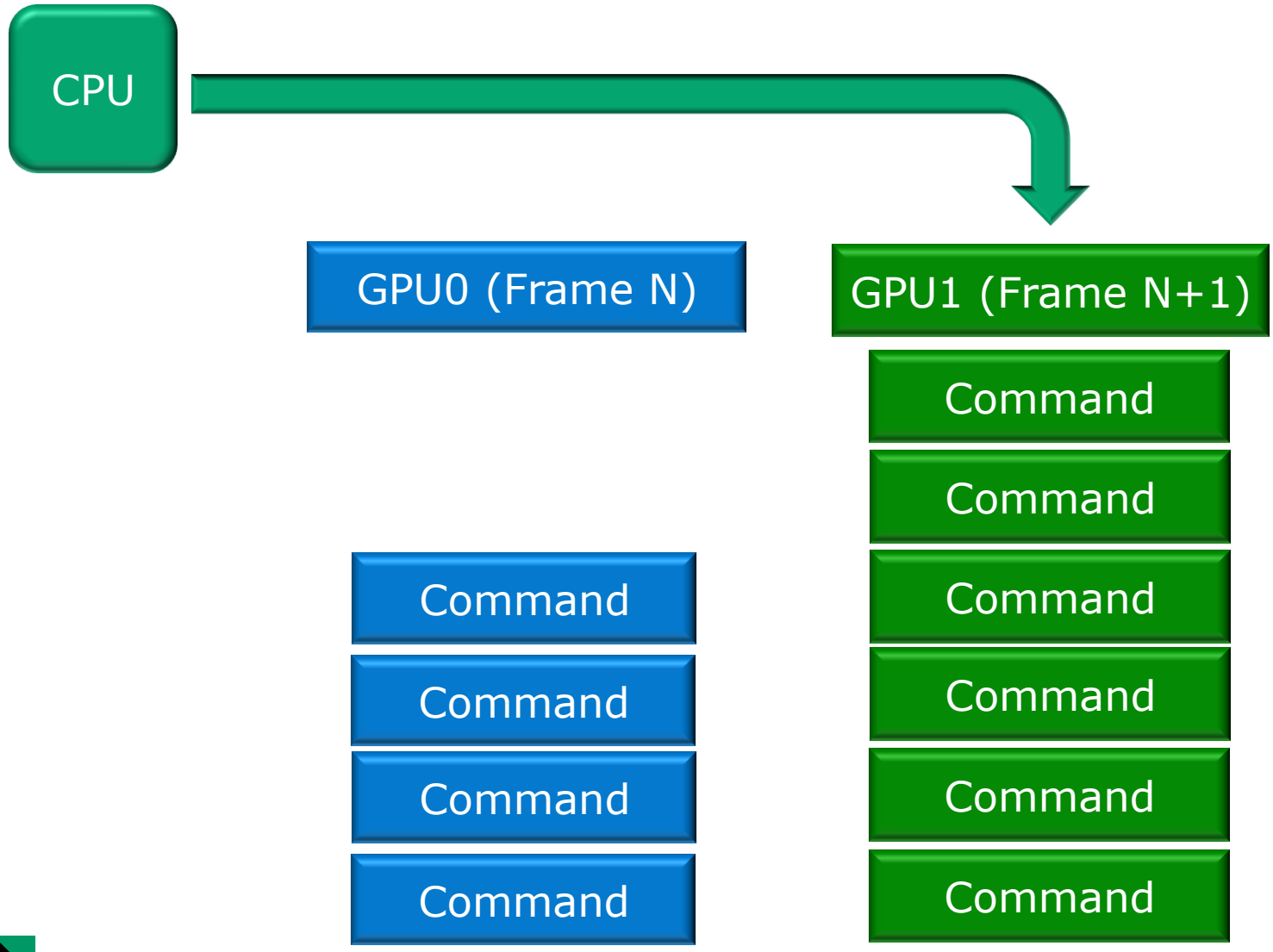
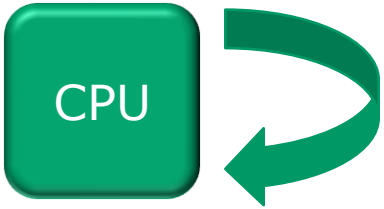


Pitfall: Waiting on Queries



Waiting for Query Result!!!

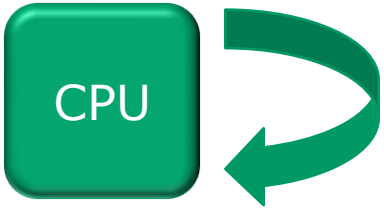
GPU0 (Frame N)

GPU1 (Frame N+1)

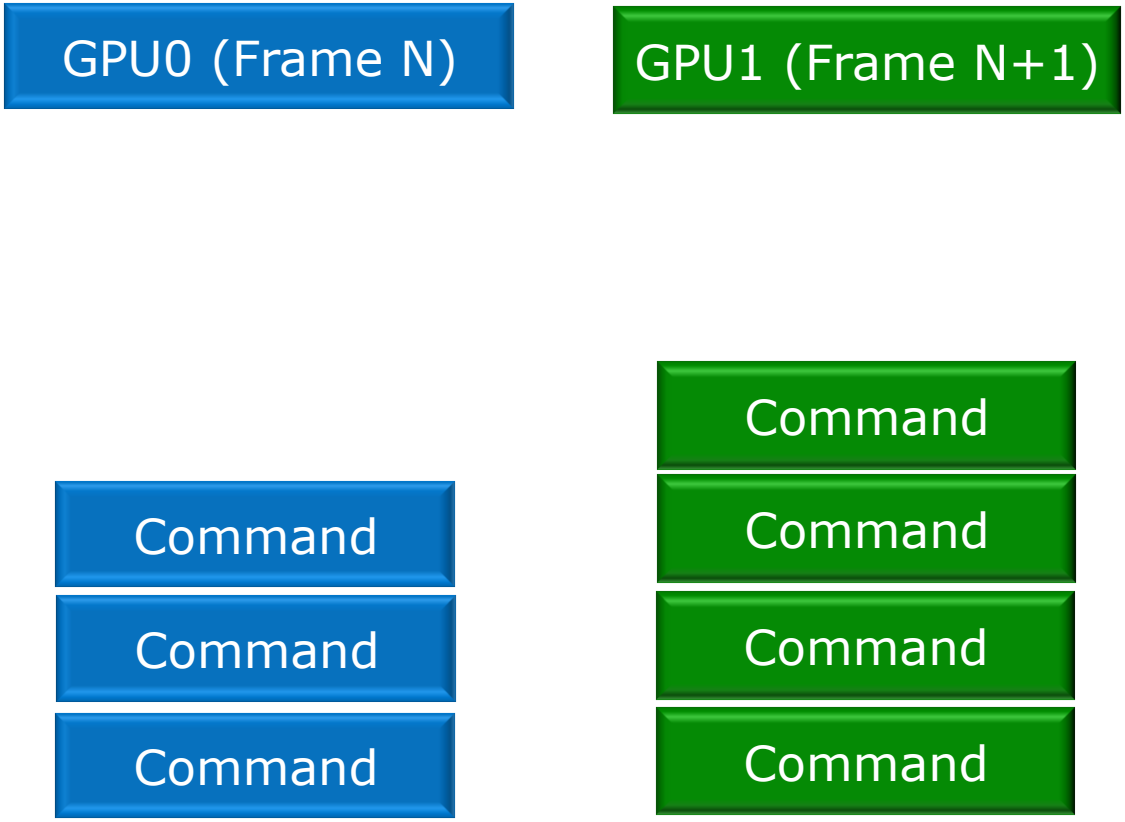
Command
Command
Command
Command

Command
Command
Command
Command
Command

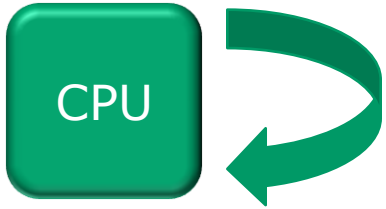
Pitfall: Waiting on Queries



Waiting for Query Result!!!



Pitfall: Waiting on Queries



Waiting for Query Result!!!

GPU0 (Frame N)

GPU1 (Frame N+1)

Command

Command

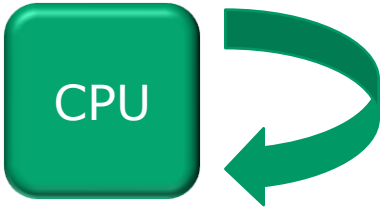
Command

Command

Command

Command

Pitfall: Waiting on Queries



Waiting for Query Result!!!

GPU0 (Frame N)

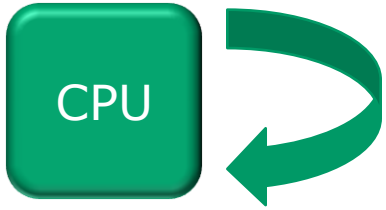
GPU1 (Frame N+1)

Command

Command

Command

Pitfall: Waiting on Queries



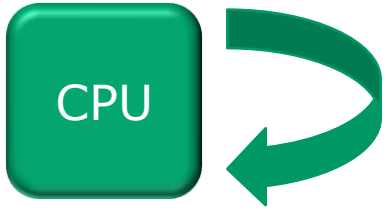
Waiting for Query Result!!!

GPU0 (Frame N)

GPU1 (Frame N+1)

Command

Pitfall: Waiting on Queries

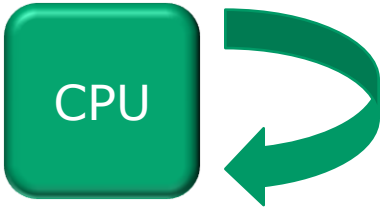


Waiting for Query Result!!!

GPU0 (Frame N)

GPU1 (Frame N+1)

Pitfall: Waiting on Queries



Waiting for Query Result!!!

GPU0 (Frame N)

GPU1 (Frame N+1)

Waiting starves GPU queues

Waiting limits parallelism

Waiting => CPU limitation

Solution: Queries

AMD
Smarter Choice

- Avoid using queries wherever possible
- Make sure that a matched pair of BeginQuery / EndQuery calls occur within the same frame
- Avoid waiting on query results
- For queries issued every frame
  - Create additional query objects for each GPU
  - Cycle through them
- Pickup the result of a query at least N-GPU frames after it was issued
- For occlusion queries consider a CPU based approach

Pitfall: CPU Access to a Renderable Resource

AMD
Smarter Choice

- When the CPU locks a renderable resource it must wait for all GPUs to finish using the resource before acquiring the pointer
- All GPUs now have to wait until the CPU unlocks the resource pointer
- After the unlock the driver has to update the resource on each GPU via P2P copies
- Just don‘t do this – it destroys performance even on a single GPU setup, and is catastrophic for MGPUs

Solutions: Locks / Maps

AMD
Smarter Choice

- In DX10 stream to and copy from STAGING textures
- In DX9 StretchRect() is always better than Lock()
- At resource creation time use the appropriate flags from:
  - D3D10_USAGE
  - D3D10_CPU_ACCESS_FLAG
- In DX9 never lock static Vertex/Index Buffers because it will cause P2P copies

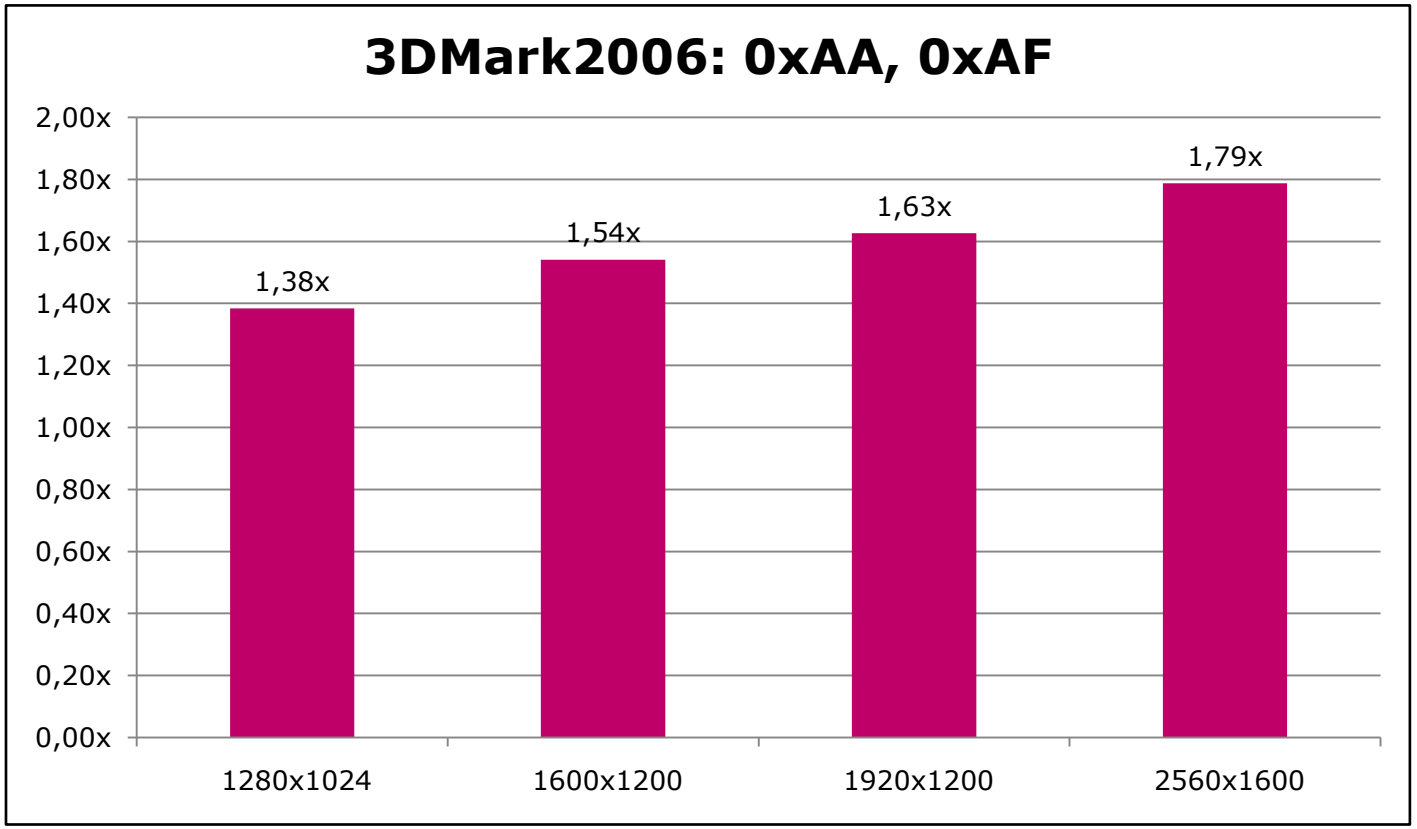
Concluding Pitfalls & Solutions

AMD
Smarter Choice

- Drivers take a conservative approach
  - Performs checks on resource synchronization
  - P2P copy if necessary
- You know the application best
  - Determine if a P2P copy is necessary
  - Talk to us about a profile
- In DX10 never use a resource shared between devices
  - No way to detect updates to resources by other applications

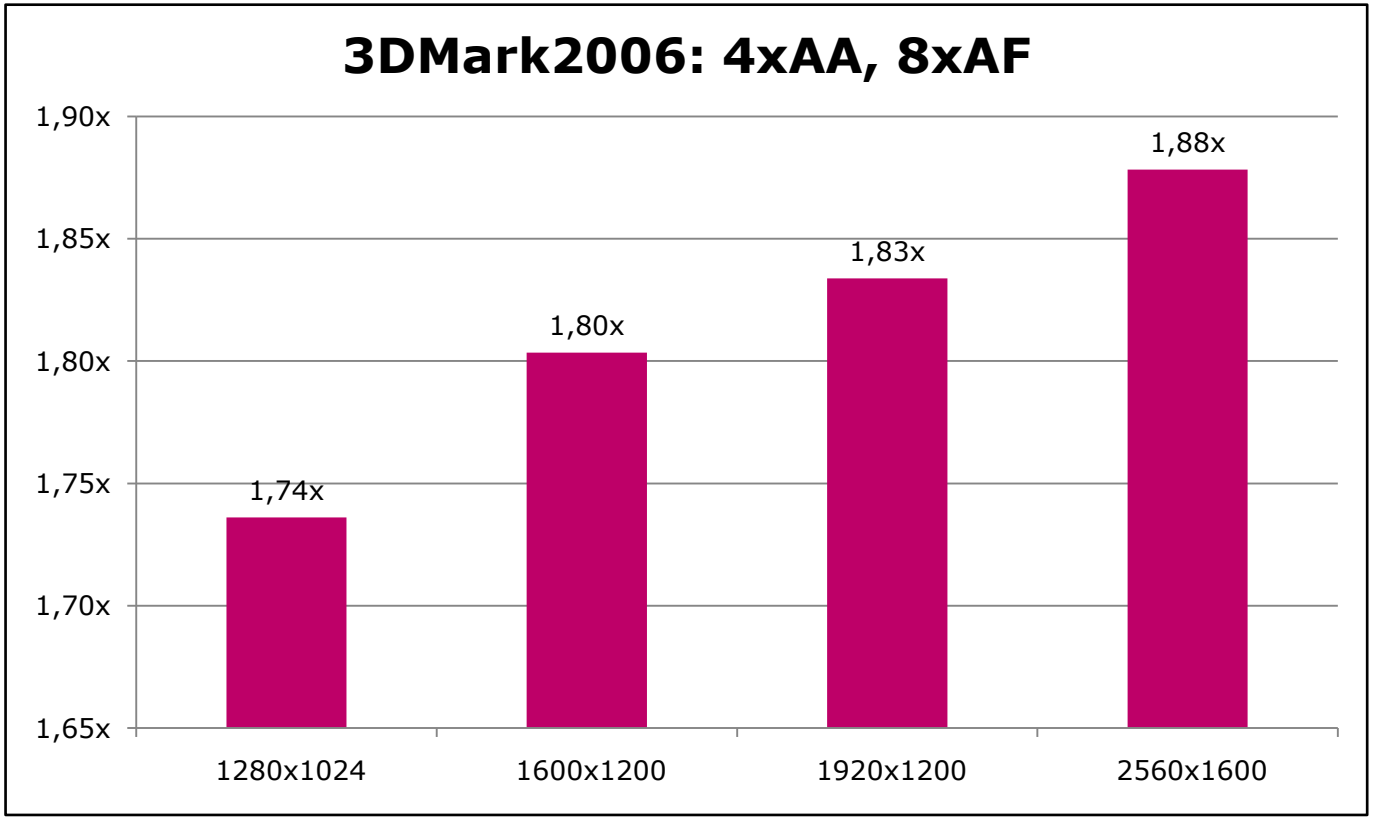
Performance Gains

3DMark2006



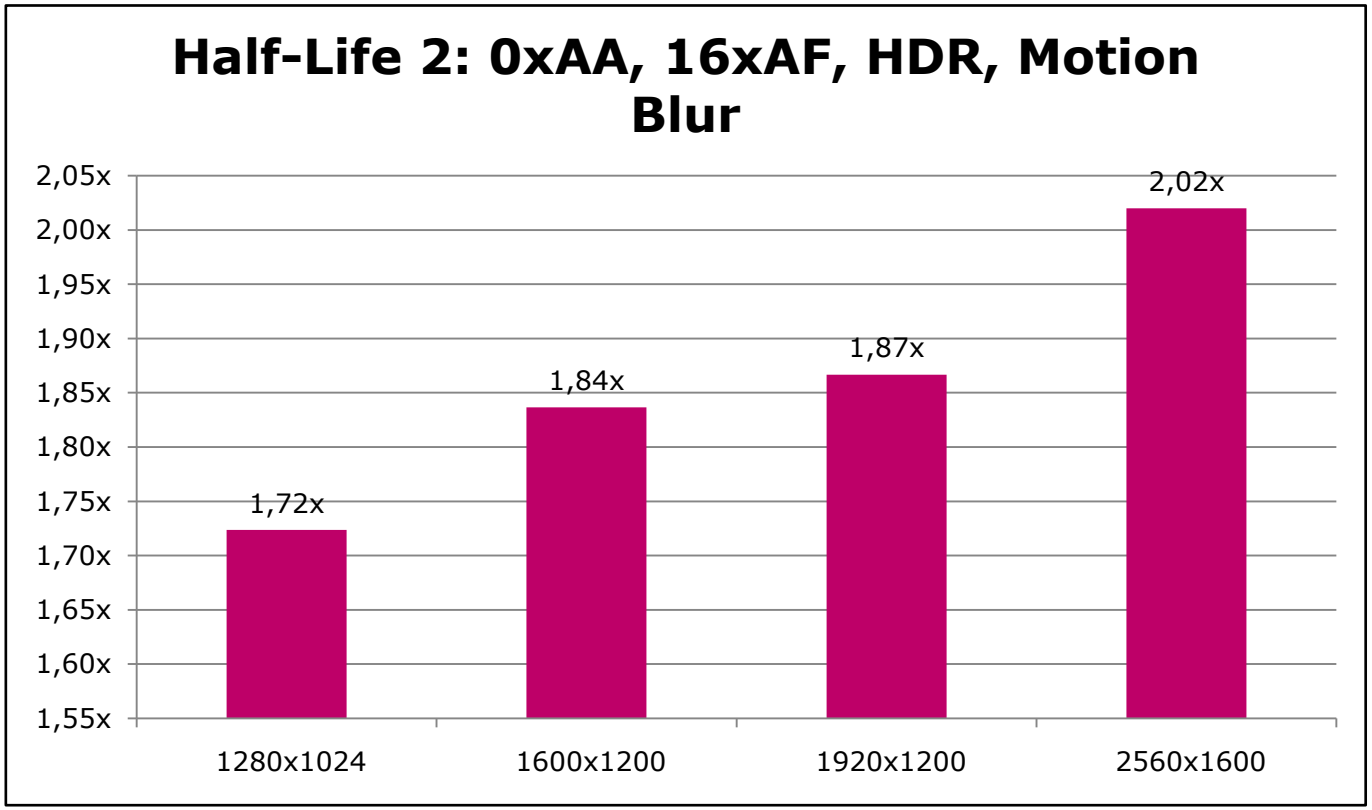
* HD3870 vs HD3870 X2 (QX9650 (3.0/1333), ASUS X38, 2GB DDR2-800, Windows VISTA64)

3DMark2006



* HD3870 vs HD3870 X2 (QX9650 (3.0/1333), ASUS X38, 2GB DDR2-800, Windows VISTA64)

Half-Life 2



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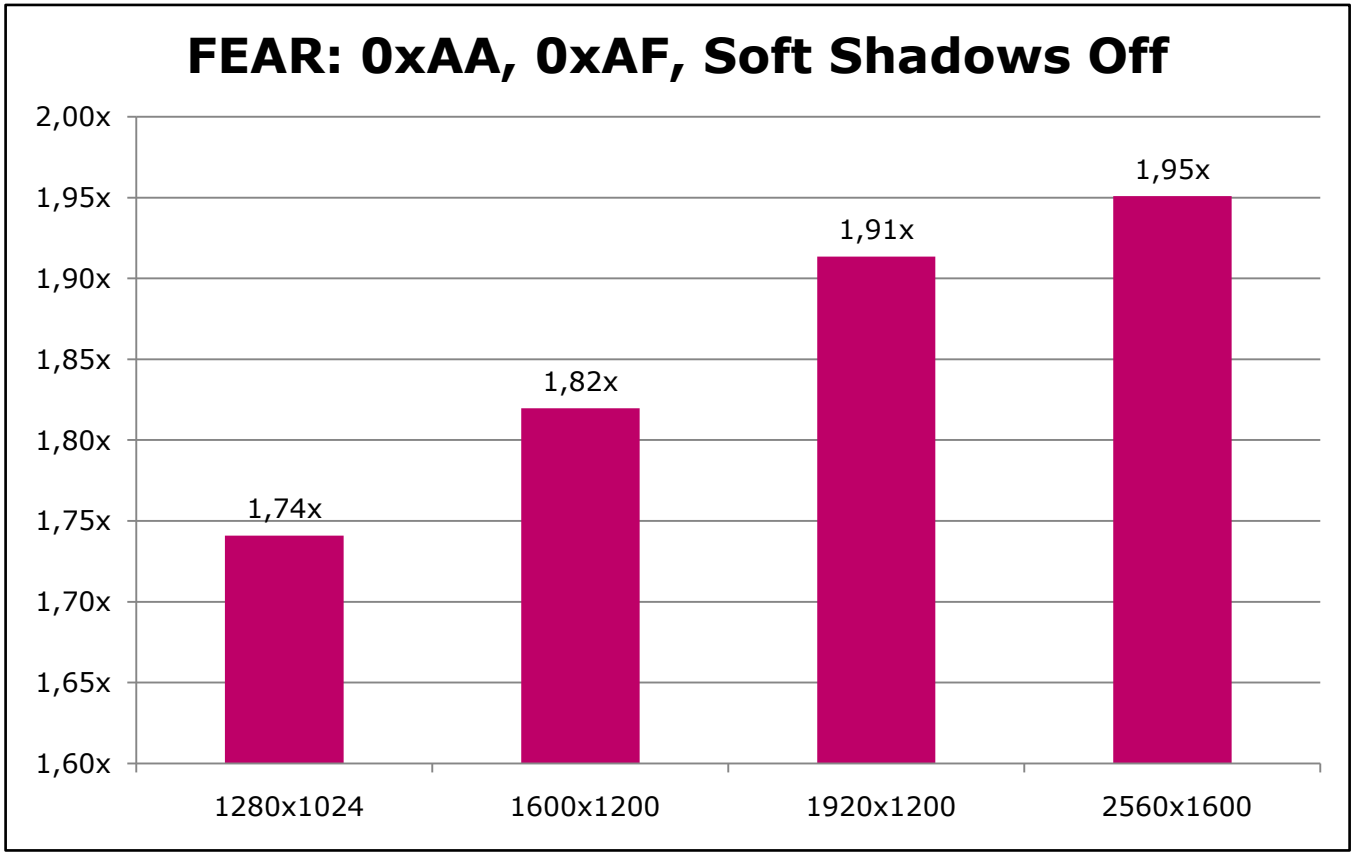
FEAR



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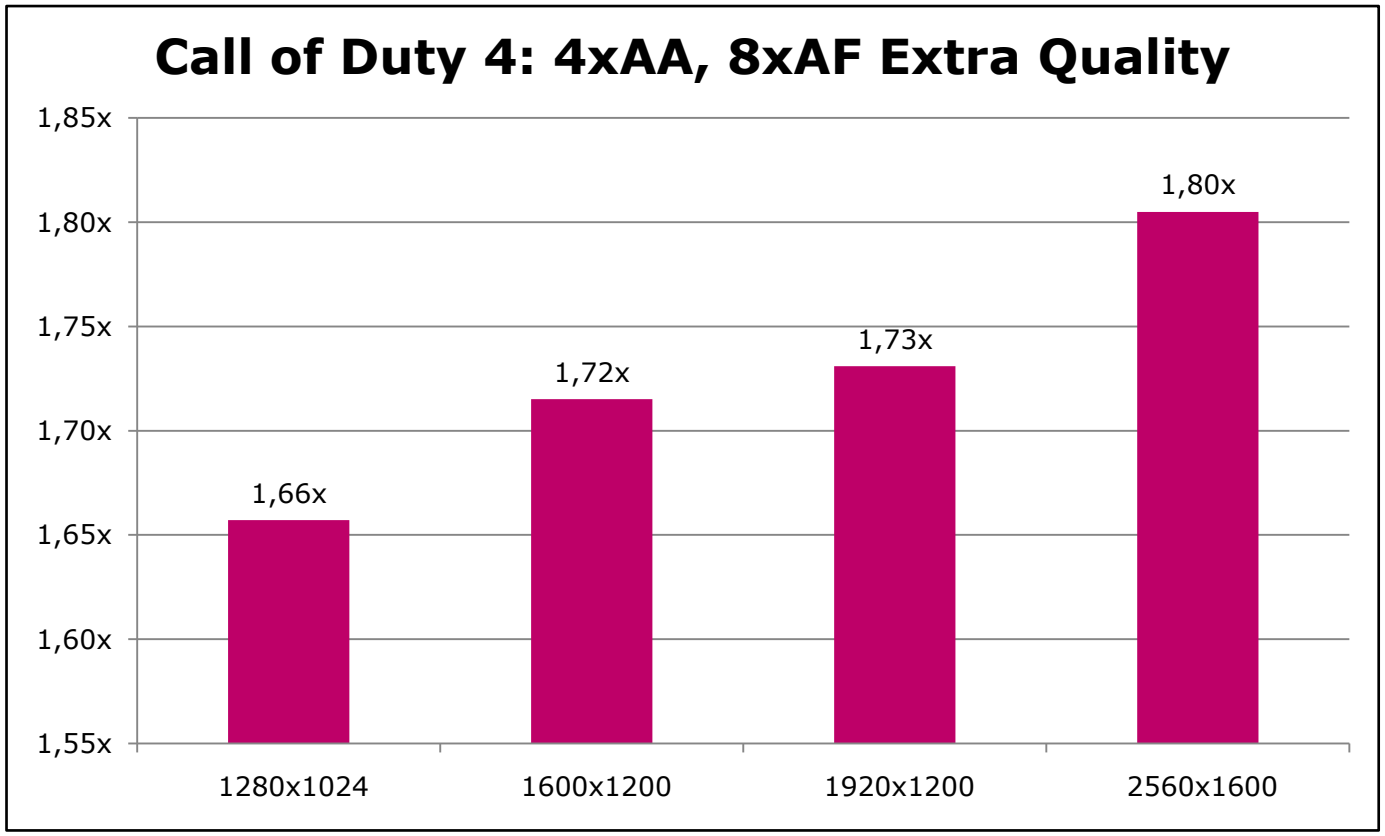
Call of Duty 4



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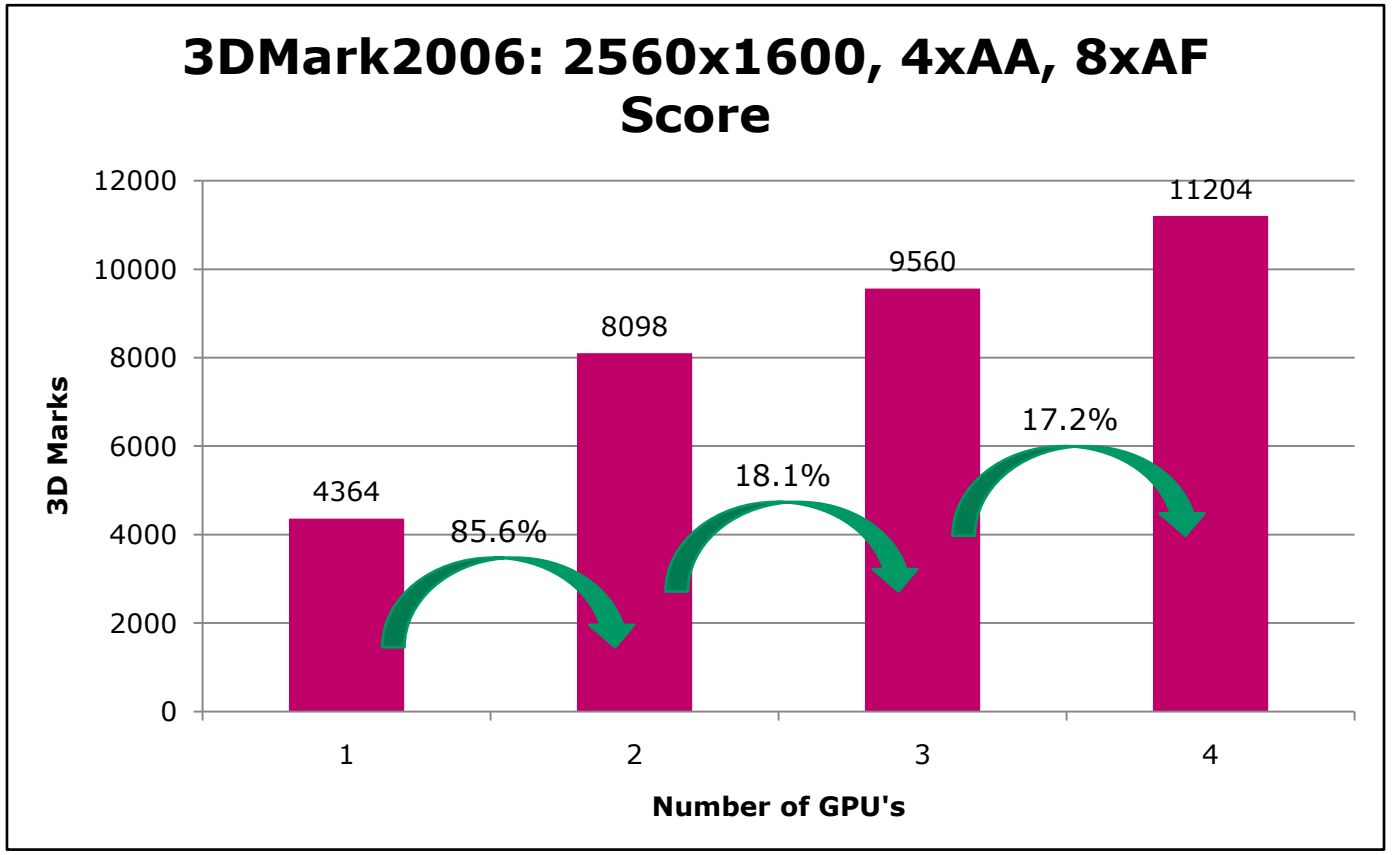
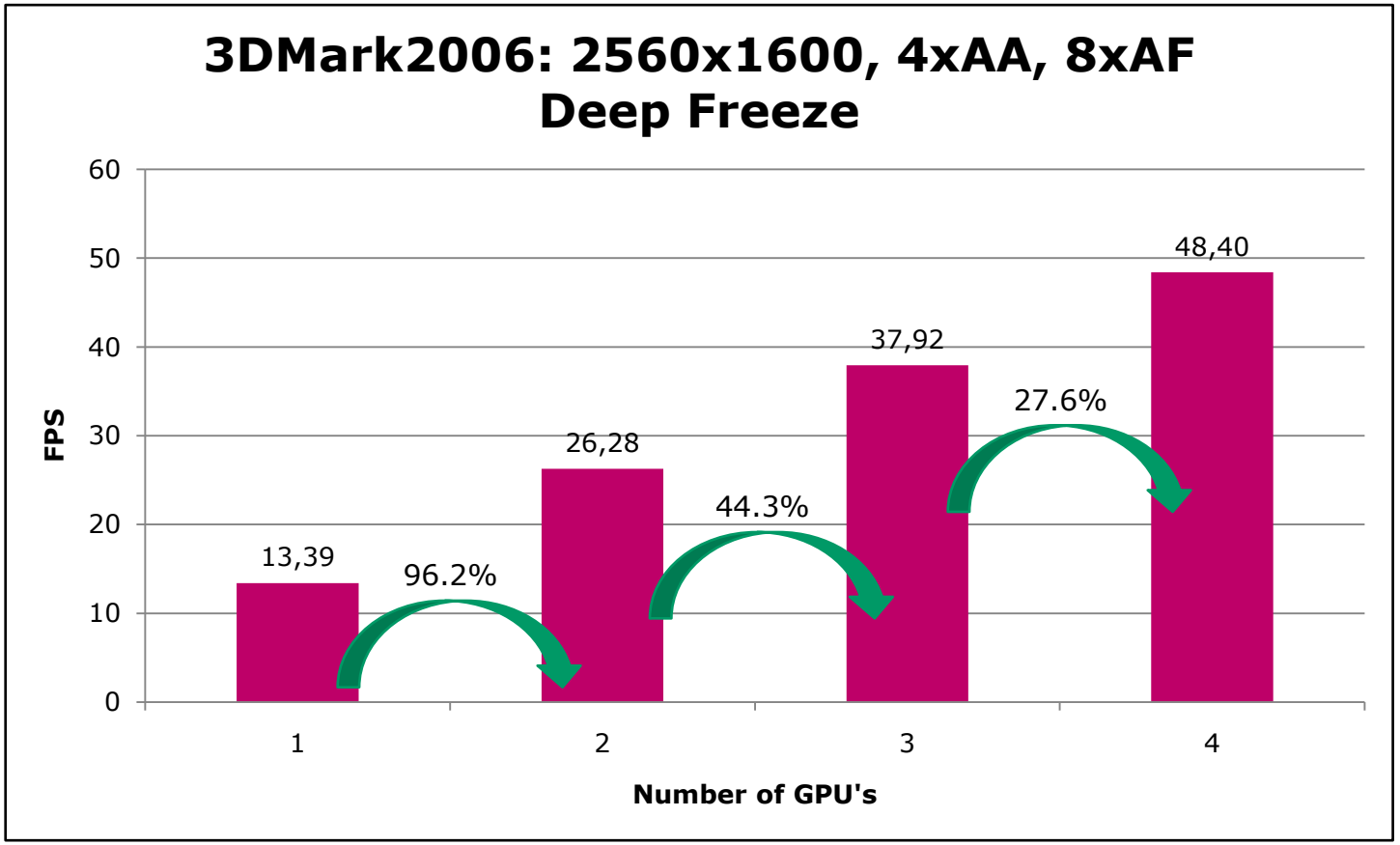
3DMark2006: 1 - 4 GPUs



* 1-4 HD3870 (Phenom 2.6GHz, MSI K9A2, 2GB DDR2-800, Windows VISTA64)

3DMark2006: 1 – 4 GPUs

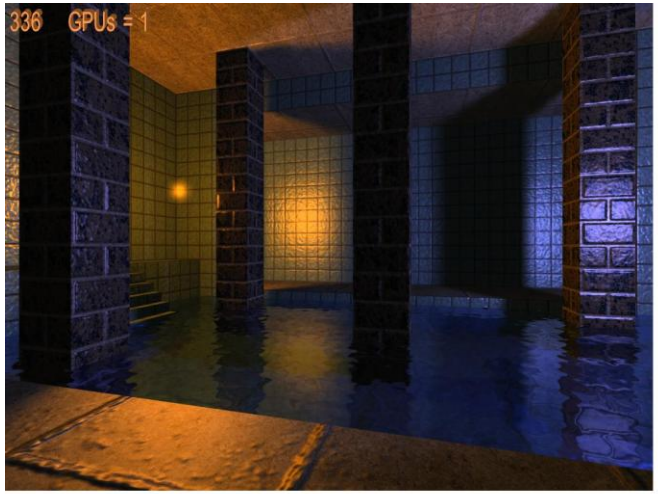


* 1-4 HD3870 (Phenom 2.6GHz, MSI K9A2, 2GB DDR2-800, Windows VISTA64)

Call to Action

AFR-Friendly SDK Sample

- Part of the ATI developer SDK
  - http://ati.amd.com/developer
- Detects the number of GPUs
- Correctly deals with textures used as render targets
- Provides a solution for dealing with mouse cursor lag
- Go and take a look!!



Call to Action

AMD
Smarter Choice

- MGPUs provide demonstrable performance gains
- MGPUs boost visual quality
- Plan from day one to make your rendering scale
  - Detect the number of GPUs
- Regularly check for AFR unfriendly behavior
- Visit http://ati.amd.com/developer
- Talk to us...
  - jon.story@amd.com
  - holger.gruen@amd.com

AMD
Smarter Choice

Please Fill in the Feedback Forms

AMD
Smarter Choice

Questions?